All About Treasures of the Earth

By

FREDERICK A. TALBOT

With a Coloured Plate and numerous
Black-and-White Illustrations

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From the picture by H. E. Millar.

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CHAPTER I

Nature's Inexhaustible Aladdin's Cave

UNDOUBTEDLY the most satisfactory feature of the industrial and commercial age in which we are living is the energy with which we are exploiting the wide diversity of materials entering into the composition of the earth's crust, for the fabrication of articles, utilitarian and ornamental, of infinite variety. We may not realise the fact, but, to a certain degree, we are emulating the man who, wishing to saw a branch from a tree, seated himself on the wrong side of his tool, with the result that when the cutting task was completed he came to the ground with the severed limb. In the same way we are digging and consuming the foundation upon which we stand. But we need not grow apprehensive that we shall fall into the raging internal fires. A thousand million or more people may be scraping away at the earth's hard rind, and participating in the consumption of the material removed, but many thousands of millions of years will need to pass before we succeed, at the present rate of progress, in scratching away sufficient of the ground from under our feet to imperil our position. Still, the fact remains that we are contributing to the shrinking of the size of the world, since, while the greater part of the material thus handled still remains with us though

in different forms, an appreciable quantity becomes converted into gas and thus escapes.

The earth is really a gigantic Aladdin's cave. It carries an inexhaustible supply of treasures in bewildering variety. The genie is the chemist, while the wondrous lamp is represented by the retorts, furnaces and accumulating knowledge with which he plies his never-ending investigations. While he is not so accomplished as the mythical force capable of producing any desired treasure merely by rubbing a marvellously endowed lamp, yet it is the friction of his thoughts, suggesting experiments, which culminates in the production of some new wonder, and which, when finally applied, opens up some new channel for human endeavour and employment.

It is the ceaseless activity in the laboratory, coupled with the innate adventurous spirit of man, which is responsible for this unremitting and minute development of the component materials constituting the earth. This activity is more pronounced to-day than it has been at any other period during the world's history. Agriculture is declared to represent the first manifestation of industry, dating from the first day of human life upon this globe. Yet it is a moot point whether it was not actually preceded by mining. If digging and delving for some treasure, even for a flint to strike a light, did not actually anticipate the cultivation of the soil, it must have followed pretty hard upon its heels, because even to-day agriculture and mining progress more or less side by side. It is almost invariably the discovery of a treasure of the earth, notably gold, which focuses the eye of the world upon some new territory. The prospector blazes the trail, scratching the earth for traces of mineral or some other valuable product, subsisting as best he can meanwhile upon the raw products of the country in the form of game, fish and wild

fruits. Upon making his discovery a wild rush ensues, humanity of every description, animated solely by one intention—to amass riches quickly—flocking frenziedly to the newly opened door of the great treasure-house. The search for the treasure gets into full swing before the issue of farming the adjacent soil for the support of the newly established community is ever contemplated, to be pursued if the conditions are considered to be favourable. Indeed, in many instances the agricultural development of many countries would never be regarded seriously for a moment, or even become possible, but for the discovery and determination to exploit mineral wealth.

How many people ever seriously considered the possibility of residing in the Klondyke previous to the discovery of gold? Was Alaska regarded as an eligible country before the unlocking of its various treasures? And how many hardy spirits would have ventured to settle in the Coolgardie country previous to the unearthing of the precious golden fleece? Yet the Klondyke to-day possesses a hustling community; acres of forest have been cleared to make way for the spade and plough. Alaska, despite the vast and forbidding polar icefields next door, the shortness of its summer and the length of its winter, is one of the finest grain-growing countries in the world. The country for miles around the Rand is an unbroken stretch of prosperous farms, while the establishment of the mining industry in the Coolgardie area laid the solid foundation for human activity in all its forms.

There is no force so powerful as the discovery of a treasure of the earth for the rapid settlement of a new country. South Africa jogged along in a quiet happy-go-lucky manner until gold and diamonds riveted the attention of the world upon this hoary corner of the British Empire. It was the discovery of

gold in Australia which laid the foundations of that country's nationhood. Up to 1851 the country under the Southern Cross had been regarded as little but an excellent convict settlement for those who preyed upon society in the Old World. In 1841 the population of the whole continent did not exceed 221,000 souls. Then came Hargreaves' sensational discovery of gold. The wondrous tales wafted to the crowded northern hemisphere fired the imagination of staid settled peoples. A tide of emigration to "down under" suddenly started up, to increase in volume with each succeeding week. The opportunity to live and move more easily in a land where there was plenty of breathing space and elbow room, and where treasure might be picked up readily, proved such a lure that ten years later—1861—the population had jumped to 1,168,000 and has been increasing ever since.

It was the treasures to be wrenched from the earth which set the United States going at a merry pace, and which opened the country with bewildering rapidity. California was but a word up till 1848. It was so remote from the accepted settled parts of the world as to be virtually off the map. But the announcement that it was carpeted with the yellow metal stirred the world. Gold led to the construction of the transcontinental railway, a monumental achievement in its day, which led to the discovery of additional treasures, and which stimulated the settlement of the huge farming country lying between the Mississippi and the Sierra Nevada. When the gold boom died down other treasures commanded attention, notably petroleum, which set up another rush to a different part of the country. Mineral discovery ushered in the State of Colorado and founded the city of Denver, one of the most important communities between the two opposing seaboards.

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A CANADIAN BACKWOODSMAN "PANNING" FOR GOLD

This is one of the most primitive methods of gold-seeking; but some of the greatest romances of mining are associated with such scenes as this.

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Nature's Aladdin's Cave

It was mineral wealth which proved the magnet leading thousands of pairs of feet from the Old World to Canada in the first instance, and the abnormal drawing properties of this force have been freely demonstrated during the past twenty years, first to the wild and wellnigh inaccessible North-West, afterwards to the more readily attainable districts of Cobalt and Porcupine in Northern Ontario, although these later rushes possibly did not compare in frenzy and dramatic incident with those of the middle years of the past century. It was the discovery of copper in dreary South-West Africa which led the Germans to build a wonderful narrow-gauge railway through two or three hundred miles of country from much of which never a penny of local revenue could be expected, in the confident knowledge that the exploitation of the newly opened treasure-house would render the line profitable.

Similar stories incidental to other parts of the world might be related. In few, if any, instances have mere agricultural possibilities served to divert the flowing tide of humanity from its normal course to their shores. In every instance it has been the announcement of a new portal to Nature's inexhaustible Aladdin's cave which has proved to be the lure. In cases these periodical rushes have led to the display of bitter feelings, not only individual, but national. The countries of the world have quarrelled over China only because it is a country rich in minerals, and because the cave it offers is inexhaustible and virtually untouched. Siberia would never have awakened from its long sleep or have been regarded as other than a prison for convicts but for the discovery of treasures untold in its remote vast stretches. New Caledonia was another penal settlement which aroused barely a fleeting interest until it was found

to be a mine of nickel. The scattered islands lying off the Pacific coast of South America were sedulously ignored until an enterprising individual found that they were rich in a treasure of another description—guano, wherewith to feed the hungry farming lands of the Old World. Similarly the heights of the Andes, facing the foregoing islands, aroused but little else than wonder from the extreme loftiness of their peaks, until saltpetre was found to exist in plenty among those apparently inaccessible snow-crowned summits. Nations have quarrelled over the acquisition of these corners of the one vast treasure-house which the earth presents, and are prepared to proceed to extreme lengths to maintain any concessions or favours which they have secured either by bluff, cajolery, trickery or brute force.

Three hundred years ago the treasures of the earth presented but a slender list. The most conspicuous were coal, iron, copper, gold, gems other than diamonds, marble and tin. To-day, to enumerate the array in full would occupy several pages of this volume. It includes substances of which our great-great-grandfathers were completely ignorant: they did not even know them by name. There is scarcely an organic material which has not come into favour for some or other purpose, either for use or ornament. If it cannot be applied to the one it is generally adapted to the other. This is due to the ceaseless activity and ingenuity of that restless genie the chemist. Three hundred years ago iron was iron; it was gathered from the rock with which it is associated and was virtually pure, that is pure in the sense prevailing in those days. The ironworker knew nothing about turning it into steel or what a variety of effects could be wrought by the addition of carbon, tungsten, manganese or vanadium, to cite but a few of the other materials which enter into its

preparation to-day, to adapt it to one or other specific purposes.

The chemist of seventy years ago would tire you out, if he could, to recite the list of materials which have come into daily use since his day. During this time men have been brought face to face with such substances as platinum, osmium, iridium, barium, chromium, nickel, carnotite, cobalt, molybdenum, radium, tantalum, petroleum, natural gas, asbestos and other materials, the mere mention of which would cause him to shake his head dolefully because they are beyond his powers of understanding.

The activity of the chemist, and the current acceptance of the precept that there is a use for everything, has played sad havoc with many traditions and has revolutionised many primitive practices. The time was when the hardy prospector set out to look for gold and gold only. But little knowledge was required to determine the yellow metal when it was spotted by hungry eyes, because there is no mistaking this mineral. But to-day the prospector sallies forth prepared to make a strike with anything. Gold may be his primary quest, but when tapping and scratching with his pick he closely scrutinises every fragment of rock which he may detach. All sand and stone is regarded with suspicion; he hesitates to discard a piece of rock having an unfamiliar coloured streak or vein running through it, lest he might learn, when it is too late, that he has thrown away a fortune. Even pebbles on the beach are regarded with interest if they depart ever so slightly from the orthodox or familiar either in shape, markings or colour; while sand will be poured from hand to hand continuously, being watched meanwhile with keen expectancy mingled with uncertainty. There may not be the slightest trace of yellow in the sand, indicative

of the presence of gold, but the prospector reflects that there are some sands carrying treasures more precious than gold—platinum, for instance, or the rare earths cerium and thorium.

The prospector, when encountered in his own domain, namely, up country, was ever as close as the proverbial oyster, but in those days he was garrulous compared with the extraordinary silence which he now maintains concerning his work, luck, and results recorded, as I can testify from personal experience. If you discreetly restrain your questioning to matters pertaining to gold he will possibly extend a civil and unequivocating reply if negative results have been recorded. But venture to inquire about other forms of wealth! He will glare at you furtively and give expression to a strange laugh which is far more eloquent than words, while to seek a peep at his specimens is almost akin to highway robbery. He says nothing lest you may be wider in knowledge than he, even if your credentials be such as to offer complete assurance that you will make no attempt to jump his possible claim. I have seen travelling official geologists and others of expert knowledge, authorities capable of extending invaluable advice on the spot, and whose bona fides could not be disputed, purposely thrown off the scent when engaged in conversation with the modern prospector. He trusts nobody, and is quite content to wait until he regains civilisation, possibly several months hence, when he can submit his specimens to unquestionable sources or impeccable officials, maybe those whom he met and mistrusted while in the bush, and be quite satisfied, though disappointed, to learn that he has drawn a blank.

The tendency to regard every piece of rock, every pebble, every handful of sand, and every drop of unfamiliar liquid as being of possible value for some or another purpose has

completely revolutionised the whole craft of prospecting. Work in this field to-day demands a man saturated with knowledge and of most methodical procedure. In fact, it is giving rise to quite a new type of treasure-finder. Yet knowledge is developing so rapidly as to demand ceaseless study in order to keep pace with progress. Even then something baffling is likely to be encountered unexpectedly.

While roaming through little known North-West Canada I met one of these nomads, a young and energetic fellow who had been right up country, far away from the outermost fringe of wandering civilisation. On the shore of one of those remote lakes in the Yukon territory he had come across some pieces of amber-like material. They were worn round and smooth by water action and were semi-transparent. What it was the prospector, although an expert geologist who had graduated through the British School of Mines and Freiburg, could not tell. It was quite beyond him. He fished his specimen out of his gunnysack with quaint enthusiasm, the knowledge that he had probably discovered something quite new prompting the action and communicative attitude. But it was strange to the party of which I was a member, although we had an experienced mineralogist among us—one who had had many years' experience in the field. It looked like amber, but it was not amber. Every test possible on the spot was made to determine its constitution, but to no purpose.

The prospector was going home, and several months later, my curiosity aroused, I rounded up our passing acquaintance. Had he solved his mystery? No. He was almost as baffled as when we had met him in the bush. He had submitted it to experts and also to industrialists to discover what it was, as well as possible applications. It had been tested and found to be an excellent electric insulator, while,

as it would take an excellent polish, it also possessed ornamental qualities. But at that time it appeared to have no really attractive commercial possibilities. So he had put it among his geological collection for reconsideration upon the day when its precise application might be determined, and when facilities might be provided to allow its cheap transport, to concern himself more intimately with deposits of silver, lead and copper which he had found. He had a lingering conviction that his mysterious piece of rock was associated in some distant form or another with petroleum, but naturally was unable to express any definite opinion upon the point.

Teasers such as these arise from time to time. Another notable example is in regard to coorongite. This is a peculiar substance, somewhat resembling india-rubber. Its presence was first observed many years ago in the vicinity of Coorong Inlet, South Australia, and on Kangaroo Island, but it aroused little attention. During more recent times, however, it has provoked greater interest, and being so far impossible of association with any known material has been christened after the name of the place where it was first picked up. At first it was believed to represent a petroleum product, and forthwith investigations were conducted in the locality to prove the existence of petroleum-bearing strata. But up to the present no success has been recorded in this direction. Consequently, coorongite still remains a mystery, and its origin constitutes a theme for academic discussion, while its possible commercial uses remain to be solved.

In the determination to win fortune from Nature's treasure-house striking ingenuity and effort are being displayed. In distant times the treasure-seekers were content to extract the wealth from large open pits, somewhat along the lines still followed for the excavation of clay for the

manufacture of bricks. But this method has its limitations. So open mine-workings, except for specific materials, has had to be superseded by burrows or mines, deep shafts being sunk vertically into the ground giving access to horizontal laterals whence the recovered mineral is brought to the vertical shaft to be transferred to the surface.

The mines vary according to the disposition of the mineral and also its character. Some mines are driven horizontally into the deposit as when it is located in a hillside and the veins run horizontally, the vertical main shaft being replaced by one in the horizontal plane. In certain instances the whole of the hillside is demolished, the ore being removed from open galleries or ledges disposed one above the other. This practice is followed in the iron-bearing districts of Sweden and Minnesota, two of the largest iron-ore yielding districts in the world.

Naturally, the sinking of a mine is a costly operation, more especially when it has to be carried to a great depth—3,000 to 4,000 feet or more—as in the case of coal and tin mining. In many instances too, where the shafts are sunk close to the seashore, it has been found necessary to push the galleries out to sea. This is the case in connection with the Durham coalfield, while the tin mines of Cornwall reach out several hundred feet under the broad Atlantic.

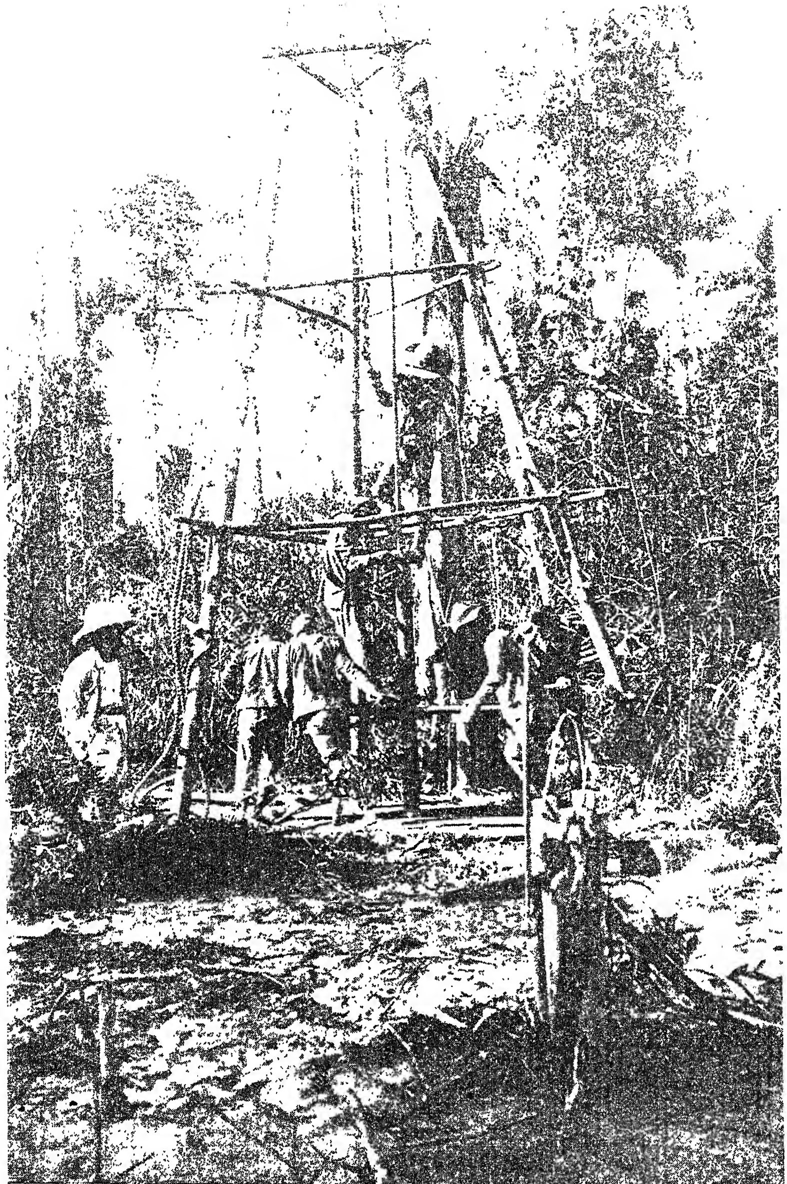
In the case of liquids different methods are practised. Mining in the generally accepted sense of the word is not pursued by means of underground galleries. The shaft, in the form of a small pipe, is driven into the earth until it penetrates the deposit underground, and the latter then rises to the surface either by its own volition or is assisted by pumping.

In some instances, and with certain materials, neither of

the foregoing practices can be adopted. This is particularly the case with such minerals as alluvial gold, platinum and other similar metals. They exist in a disintegrated form, but associated with sand, mud and detritus. To recover the wealth desired in these cases, powerful dredgers are employed which bring the river bed to the surface by means of buckets mounted upon an endless belt travelling over a long ladder-like structure, one end of which is lowered and pushed down into the river or sea bed. The buckets, in rounding the bottom end of the ladder during their travel, are forced to scrape the surface of the bed and in this way bring the spoil to the surface for treatment.

Situation, nature of deposit, and character of the wealth being won, determine the character of the system to be employed. No hard and fast rule can be laid down. In some instances one may witness a limited application of the three systems side by side, the one catching what the other misses and in this way rendering recovery more complete, and of course more profitable. But the variety of methods in vogue serves to widen the scope for employment as well as extending choice of field for specialisation.

The ingenuity which has been, and still is being, manifested, by the chemist and also the engineer has been responsible for world-wide activity. The treasure-house of Nature may be inexhaustible, but it is being attacked from every conceivable point of vantage. One door is being forced at an altitude of 11,000 feet or more above the sea level, while another is being unlocked from 4,000 to 7,000 below the surface. Neither intense cold nor intolerable heat can stop the treasure-seeker. Thus we find coal being won from lonely Spitzbergen, where King Frost releases his tight grip for only a few weeks during the year, gold from within the



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DRILLING FOR MINERAL TREASURE

Tin is found in many parts of Malay in all kinds of soil, at the grass roots and down to a depth of 250 feet.

Arctic circle, silver from among the clouds in the Andes, tin from the sweltering jungle of Malaya, and divers other treasures from swiftly-running broad rivers in such remote corners of the earth as northern Siberia, the Straits of Magellan, the serrated coast-line of Tierra del Fuego, the sandy strands of Brazil and India and the torrid sweltering sinister Death Valley. But the prizes are so attractive as to make widespread appeal, while the work carries that atmosphere of incident and adventure, as well as the opportunities for conquest, so irresistible to the human race.

CHAPTER II

The Wonderful Spouting Bores of Australia

THE following chapters are devoted to the winning of what may be described as the universally accepted intrinsic treasures of the earth, to obtain which, as well as fortune, the more intrepid among men are willing to embark upon bold and hazardous adventures into the unknown; to suffer hardships and privations untold. Yet there is one treasure excelling in value all those which will be mentioned, because it is absolutely imperative to the acquisition or conversion of all the others to commercial account. This priceless treasure is water.

Many people may feel disposed to smile at the suggestion that water is more valuable than gold or diamonds, coal or iron. But this is only because they are so familiar with water in all its varied forms as to be unable to realise the extent to which this commodity enters into every expression of industrial and other activity. We in Britain, for instance, scarcely ever pause to reflect that our wealth is indissolubly associated with water, because we are unable to picture what would happen were Britain to be transformed suddenly into a sterile country. The majority of us are disposed to think, at least at times, that Nature is disposed to be a little too generous towards us in her distribution of this gift, and doubtless would willingly barter our apparent superfluity thereof with

some other country for one or another more highly prized and widely accepted treasure of the earth.

Yet no country can possibly hope to thrive unless bounteously endowed with water. It is the force which keeps the wheels of life and industry steadily turning. If we wish to satisfy ourselves upon this point we have only to turn to countries where the rainfall is insignificant, and to reflect upon the millions of pounds which are being expended to irrigate the land and to conduct adequate supplies of this commodity to isolated humming hives of endeavour. Its discovery would transform the Sahara and other sizzling stretches of dismal sand into wondrously beautiful gardens and incalculably fertile farms, and would enable much mineral wealth at present lying dormant to be recovered for utilitarian or embellishment purposes, and which would lead to the foundation of bustling cities, towns and prosperous villages. Until such time as adequate supplies of fresh drinkable water are found these areas must be suffered to remain ugly, forbidding and useless sun-baked blotches shunned by the human race.

To grasp in a realistic manner the precise and extraordinary benefits accruing from the availability of such supplies, as well as to form some idea of the lengths to which man will go to remedy superficial deficiencies, we must look at Australia, which, as we all know, is the world's sheep farm. In Australia the sheep roam the undulating pastures, not in their thousands, but in their millions, to furnish meat for food and wool for clothes to the teeming populations of Europe. Few people who have not been to Australia have the faintest conception of the immensity of the flocks to be seen in the remote continent, while the mere iteration of figures fails to stimulate the imagination. In 1915 the

farmers of Australia were the owners of 70,000,000 head of sheep, which provided Britain with approximately one-half of her total wool requirements, the precise figure being 426,163,648 lbs., which were valued at £19,447,337. This was exclusive of New Zealand, which contributed a further 200,031,839 lbs., worth £11,075,927, the grand total derived from "down under" being 626,195,487 lbs. of wool, for which £30,553,264 was paid. The precise extent of Great Britain's dependence upon Australasia for fleece may be gathered from the statement that the total importations of wool, during the year in question, from all parts of the world, totalled 926,380,036 lbs., the value of which was £42,027,335. Yet the 70,000,000 sheep which grazed the succulent Australian grass in 1915 did not represent by any means high-water in point of numbers, because it was in 1891 when the top figures for the Commonwealth were established, the ranches of the Commonwealth in that year being populated by no fewer than 106,000,000 of these animals.

With such immense armies of sheep the anxiety of the farmers concerning adequate supplies of water may be imagined. For many years it constituted their one topic of conversation and source of apprehension. Pastures are as useless as goldfields if there be no water, and the squatters were speedily convinced of this circumstance when the sheep-raising industry commenced to develop, because the great grazing lands of Australia are woefully deficient in all-the-year-round surface supplies of this commodity. To make matters worse, the grazing areas lie within what may be called the great drought belts. During the dry season the mercury in the thermometer flies upwards to notch, in the hottest parts of the country, when the summer is dry, 120

degrees Fahr. in the shade, while, in the driest parts of the Commonwealth, the rainfall does not exceed ·10 inches during the round twelve months.

Little wonder, therefore, that thirty years ago the stock-raisers viewed the approach of the dry season with unfeigned dismay, while the drought was regarded as an unmitigated scourge. The sheep, impelled by thirst, wandered far and wide seeking the scattered springs and holes yielding limited supplies of water. In several instances the miles to be covered were many, the going was heavy and exhausting, while the heat was prostrating. Many animals fell by the wayside, and unless promptly succoured suffered death. The scenes witnessed around the water-holes, the supplies from which during the most severe droughts were extremely slender, were heart-rending. Imagine a puddle from six to ten feet in diameter and you can form some idea of what constituted a water-hole upon the Australian plains. The animals, weakened by their long journeys, hot and well-nigh mad with thirst, upon scenting the water would plunge madly forward, and upon reaching the precious liquid would fight and scramble frenziedly to cool their parched throats. In the wild mêlée the weaker were thrown to the ground to be trampled under foot. The water itself was churned up, and thrown and splashed in all directions by the frantic pushing and jostling of the animals, converting the approach to the water-hole into a quagmire, into which many animals would be flung to be smothered alive. Even when an animal, by sheer display of strength, succeeded in reaching the hole and slaked its thirst, it often suffered a lingering death from suffocation in the treacherous tenacious slime.

The mortality among the flocks during the droughts rose to an appalling level. Squatters who counted themselves rich

in the spring, from the numbers of their sheep, realised only too poignantly that by the autumn they might be reduced to straitened circumstances from their heavy losses. They strove might and main to mitigate the possibilities of disaster, resorting freely to elaborate and expensive devices to catch and to hold the priceless liquid against the days when the sun would beat down savagely, and the air would become as hot and dry as a sirocco-swept desert.

The climax came in 1885. The drought was of abnormal severity during that year, and held, so it seemed to the disheartened stock-raisers, for an interminable length of time. But worse even than the drying up of the scanty supplies of water for the millions of animals was recorded. Many of the towns and villages lying within the dry belt found themselves threatened with disaster, if not absolute extinction owing to lack of water.

Then it was that small expeditions of hardy venturesome men were formed. They saddled themselves with light outfits of tools so as not to impede their free and rapid movement. In the garb they assumed they recalled the picturesque pioneers of the gold trail. They were prospectors and miners, not only in appearance, equipment, and temperament, but in their intentions, only they were not bent upon the search for, and unlocking of, new treasure-houses of gold, gems, or the more utilitarian minerals of this age. They were armed to prospect and to dig for *water*.

Scientific investigation, as revealed by the activities of the scientist, had indicated that, while little respite could be anticipated from the heavens, and that little or nothing was to be expected from the water flowing upon the face of the earth to succour the sheep, yet these two deficiencies might be readily remedied were the waters under the earth only

tapped. Investigations pointed to the existence of gigantic thickly-roofed reservoirs buried deep beneath the scorched floor of the continent. If it were possible to drive through the hard crust imprisoning this water then, perhaps, the whole problem of watering the sheep roaming the plains might be solved, and defiance hurled at the most scorching drought.

That geological reasoning was correct had been established many years previously. In 1879 drilling was taken in hand at Kallara, New South Wales, and at a depth of 140 feet the drill crashed through the last layer of earth forming the roof to the natural subterranean reservoir. The released water gushed forth so impetuously as to fly 26 feet into the air, forming an impressive fountain. In 1884 the State Government embarked upon a second similar enterprise, and again success was recorded, a small supply being tapped at a depth of 89 feet. Other states embarked upon methodical prospecting and drilling for water, and their efforts testified to the abundance of this commodity under the earth, and proved that if due exertion were expended to provide the necessary vents it might be brought to the surface, where it was in such urgent request.

All anxieties and worries which had harassed squatters, sheep-raisers, and dwellers in the inland towns and villages disappeared. A new industry was established—mining for water, or, as it is locally termed, the drilling of artesian bores. Territories which up to this time had been regarded as plague spots, lands of blasted hopes and lost fortunes, and accordingly had been studiously avoided, recorded a startling change. Unprecedented rushes set in; settlement proceeded apace, and the flocks of sheep increased in numbers at an amazing rate. As every schoolboy knows, the Australian

Commonwealth is subdivided into five self-contained federal States, each of which assumes responsibility for its individual welfare, progress, and the development of its native resources. But the exploitation of the underground stocks of water was prosecuted diligently and simultaneously in each territory, the degree of activity being adapted to local requirements.

This mining for water was encouraged by the results of the careful investigations conducted by the official geological experts. They found that these subterranean supplies are spread over immense and distinct tracts, or, as they are called, artesian basins. The largest, known as the Great Artesian Basin, covers approximately 560,000 square miles. A comprehensive idea of the gigantic dimensions of this subterranean reservoir may be gathered when it is remarked that it is nearly seven times as large as England and Scotland combined. Of this vast tract, about 376,000 square miles lie under Queensland; 90,000 square miles under South Australia; 83,000 square miles reach under New South Wales; while a small patch of 20,000 square miles projects under the south-eastern corner of the Northern Territory. In addition to this huge, irregularly shaped underground lake there are six other basins, each of smaller area, distributed along the coast, five of which lie under Western Australia, while the sixth, known as the Murray River Basin, is almost wholly within the State of New South Wales.

For the most part the water is found in the porous rocks or sandstone which covers a vast tract of England, and which is familiarly known as the New Red Sandstone. From its peculiar porosity it constitutes an excellent water-bearing stratum. Even in England the water drawn from this vast

"sponge" plays no little part in the creation of wealth, because it is the source of the water with which the distinctive Burton beers are brewed.

The water suffers imprisonment in this water-bearing stratum for the reason that it is wedged between two layers of impervious earth. If the upper crust be weak at any point, or a fault exist, the water, by its pent-up energy and searching character, will discover the weak fetter, burst it, and make its way to the surface, taking advantage of every crack in the superimposed strata to effect its escape. It is these faults which feed the water-holes of Australia and which led the geologists to conclude that abundant liquid was being held in a prison from which it could only escape with difficulty and in limited quantities. Beneath the water-carrying layer forming the bed of the underground lake is another formation, probably of dense rock or clay, through which the water cannot pass in the downward direction. But water is energetic in its search for an outlet. If it can neither ascend nor descend it wanders along the horizontal plane, being forced to do so by the never-ending supplies pouring in at the various elevated points of the water-soaking stone, and thus applying pressure from the rear. It may wander aimlessly for hundreds of miles, but sooner or later it finds an open door, through which it trickles or rushes according to the conditions which obtain. In the case of the Great Artesian Basin the water is declared to flow steadily upon a falling underground journey of a devious character under the Continent to pour finally into the Great Australian Bight.

It will be seen that once the upper impervious layer of earth forming the lid to the underground cistern is penetrated, the water within, taking advantage of the oppor-

tunity, will surge upwards through the hole until it finds its own level. Possibly the level will be below the mouth of the bore-hole, in which event the water will need to be assisted over its final stage of the journey to the surface by means of a pump. In many instances, however, there is sufficient pressure to lift the water, not only to the mouth of the bore-hole, but to throw it high into the air.

This is the case in Australia. In many instances the water, as if excited at its opportunity to gain freedom, flings itself madly into the air, to form a majestic gusher or fountain, the top of the plume being some sixty or more feet above the mouth of the pipe. Obviously, in sparsely settled territories, where labour and fuel are difficult factors, such inherent volition is extremely fortunate. It relieves the authorities, whether they be private or official as the case may be, of the necessity to instal a pumping plant, the transport of which to the site would not only be difficult but expensive, and to avoid heavy charges in regard to operation which would otherwise be incurred if fuel had to be brought in, and which would inflate the cost of the water to a pronounced degree. But when gushing forth freely the water is procurable at the minimum of expense—the cost of sinking the bore.

Drilling is conducted along the self-same broad lines as are followed when tapping the interior of the earth for petroleum, and the work associated with which I have described in another chapter. The bore-holes driven in this manner are known as artesian wells from the fact that the principle was first applied to the recovery of water as long ago as 1126, in the French province of Artois, then known as Artesium. The boring tool comprises a drill, which is sunk vertically into the earth. As it descends, the

hole which it makes is lined with a pipe or casing, the iron wall being carried down as the drill descends merely by attaching additional lengths to the upper end.

In such proved water-bearing territory as the Great Artesian Basin, mining for water is virtually relieved of all hazard of uncertainty. But while the discovery of water may be said to be positive, that is not to say that the supplies tapped will be suited to their intended purpose. Many disappointments are encountered in connection with this work, even in Australia. The waters drawn from these wells vary widely. Thus, that drawn from the Eucla Artesian Basin, fringing the southern coast of Western Australia, so far has been found to be salt or brackish, and virtually useless. This circumstance points to the sea having access to the porous rock stratum or the existence of subterranean salt deposits. Other artesian well waters upon submission to analysis have been discovered to be undrinkable both by man and beast, but can be used for scouring wool, and so are restricted to such use. This is particularly the case in Queensland, where certain waters have also been found suitable for drinking purposes, possibly only for stock, but which cannot be employed for irrigation, owing to the presence of alkali. Other wells yield water which may be used both for stock and the slaking of the thirst of crops. Generally speaking, water which, despite its slight mineral taste, can be used for sheep and other animals, is generally safe for human consumption, it only being necessary to become familiarised with the peculiar flavour. But some of the wells yield water of a decided mineral taste, and these have met with widespread application after the manner of Vichy and Perrier mineral waters. Those of this character which may be cited as possessing a commercial value for table purposes are

respectively "Boonah Spa," "Helidon Spa," and "Junot Spa." These have a decided vogue throughout Queensland and New South Wales either as straight mineral waters or for the preparation of compounded drinks, and for the most part are derived from shallow wells ranging in depth from 60 to 200 feet.

Occasionally the water drillers meet with dead failure. This is particularly the case if the water be impregnated with sulphuretted hydrogen, which is highly offensive both to the nasal faculty and to the palate. It is of no commercial use whatever, and such "strikes" are promptly abandoned, being shut off to frustrate possible contamination. Shutting down is an easy operation, it being only necessary to seal the bore with an iron cap or to block the bore-hole. Curiously enough, while a bore sunk at one point may be rankly offensive in point of sulphuretted hydrogen, another bore driven a short distance away will yield an excellent drinking water, totally free from the odoriferous and unpalatable constituent associated with the first bore.

Thus it will be seen that even in the best proved areas, mining for this treasure of the earth is not free from what might be termed mild excitement, mingled with a dash of uncertainty or failure. It is distinctly galling to bore into the earth's crust for several hundred feet and to strike water in plenty only to find it to be of no possible use to man, beast or commerce. Another source of exasperation is the excessive action of corrosion, which is likely to destroy the casing to the bore-hole. The water is apt to be heavily associated with sand and stones detached from the "sponge" rocky stratum. Naturally, when the water rushes madly upwards this detritus is borne along with it and rubs against the interior surface of the casing. If the volume of material

be appreciable, and pronounced friction result the casing will be speedily worn out. Attempts to mitigate this evil have been made by utilising a hard wood instead of metal for the casing, and a certain measure of success has been achieved.

The State of Victoria has been somewhat unfortunate in drawing blanks, or conducting work which has subsequently proved to be abortive. It lies outside the Great Artesian Basin, but, on the other hand, water has generally been found to be plentiful at shallow depths, so that recourse to artesian boring has not been so essential as in other parts of the continent. The first bore-hole was put down at Sale in 1880. It flowed excellently for a time and then trickled out owing to the erosion of the casing. Nothing was done for fifteen years, when it was decided to put down another bore. At 277 feet sufficient water was struck to fill an adjacent depression. But the water was below the requisite standard; it was too heavily charged with sulphuretted hydrogen to be used. Forthwith boring was continued to 520 feet when, owing to the lowering of the casing, the supply stopped. A second bore was taken in hand upon a fresh site, some distance from the first, and at 238 feet, owing to a yield of some 145,000 gallons a day being tapped and being found of excellent quality, the drillers congratulated themselves upon their good fortune. Their success was shortlived, however. Corrosion troubles were soon experienced, and proved so exasperating as to demand the drilling of a third bore, which was carried down to 235 feet to tap two superimposed flows, the higher being at 187 feet.

It was the severe drought, precipitating failure of the surface supplies, recorded during the period 1878-1886, which stimulated more accentuated activity in the driving of bores

in the State of Victoria. Before the end of 1888 no fewer than 499 bores were driven, aggregating 40,000 feet, throughout the settled stretches of the State, of which only 78 were fruitful in the true sense of the word and yielded potable fresh water. Of the bores driven, 229 struck salt water, while in an additional 47 cases the liquid was brackish but usable. The outstanding 145 were dry. During the period of the eighties, bores were made in the north-western part of the State, but no notable successes were recorded, although the drills were carried down to 2,000 feet. In another instance eight bores were put down during 1906, but not one yielded water suited to human consumption. Another area was tested in 1908, and 87 successful strikes were made, supplies of underground water being secured from depths ranging between 155 and 752 feet.

The cost of winning this treasure from the underground reaches of Australia varies widely, naturally being governed by the depth to which it is found necessary to drill—the greater the depth the heavier the cost. Thus, in certain parts of the continent, the charges are approximately as follows:

From surface	to	1,000	feet	deep	30	shillings	per	foot.
,,	1,001	,, 1,500	,,	,,	35	,,	,,	
,,	1,501	,, 2,000	,,	,,	40	,,	,,	
,,	2,001	,, 2,500	,,	,,	45	,,	,,	
,,	2,501	,, 3,000	,,	,,	50	,,	,,	
,,	3,001	,, 3,500	,,	,,	55	,,	,,	
,,	3,501	,, 4,000	,,	,,	60	,,	,,	

and so on, at the rate of an extra five shillings per foot for each additional 500 feet. Thus, whereas a shallow bore may cost no more than £210, drilling to a depth of 4,000 feet for

the elusive water will involve an expenditure of £8,625. The work is carried out by private and official enterprise, the last-named being represented by both the State authorities and the local governing bodies. Under official conditions the work is executed at a lower figure, the official charge in New South Wales, for instance, being about 50 per cent. less than that obtaining under private enterprise, especially in connection with shallow boring.

In driving the bore it is necessary to carry the drilling to a sufficient depth to ensure a continuous flow of adequate volume and not to be deluded by a false strike such as a pocket might present. When driving the Charleville bore in Queensland the drillers struck water at about 175 feet. It proved to be only a pocket, and the boring tool had to be sunk a further 1,135 feet before another copious flow was reached. Even then, though the water ascended the drill-hole, it did not fly into the air. The drill resumed its monotonous chugging, but had only bitten through another 60 feet of the dense hard crust when there was a roar and a rush, the water spouting high into the air to settle down to a steady flow of 3,000,000 gallons a day. Three months were occupied in reaching the treasure at this point.

The State of Queensland can point to some magnificent spouting bores, great activity in sinking artesian wells having been manifested in this State, owing to the extreme scarcity of normal supplies. Altogether the crust of the continent lying within this territory has been punctured by 2,816 drill-holes, a goodly number of which, however, have had to be abandoned or are uncertain. Still, there are over 1,000 freely flowing bores belonging to the State and private owners, the last-named being in overwhelming majority. The aggregate flow of water from these wells during the twenty-four hours

runs into billions of gallons. Only about 100 furnish less than 10,000 gallons a day. A round 900 yield from 10,000 to 1,500,000 gallons daily, each of 500 of this total giving from 100,000 to 500,000 gallons during the day. Approximately 20 bores give from 1,500,000 to 2,000,000 gallons, while there are about half a dozen furnishing over 2,000,000 gallons apiece each twenty-four hours.

The water, once released, is not permitted to pour from the bores at its own merry pace and volume. It is brought under strict control. A gate and valve are fitted to the mouth of the casing, wherewith the water can be adjusted to a mere trickle or a vicious fountain, or, if desired, can be shut off completely. Water is too valuable to permit indiscriminate waste or to furnish even spectacular fountain displays. A suitable basin is excavated around the bore, so that sheep and cattle may drink in plenty and in comfort, the purpose of the bore being to keep the lakelet adequately filled with fresh, clear and sparkling water. In some instances it is even distributed through conduits over a large area. This is the case in New South Wales. In this State there are a round 500 bores, representing a total depth of 420,024 feet. The flow from 72 of these bores, aggregating 38,124,836 gallons per day, is distributed through 2,702 miles of drains, and thus assures the adequate watering of 4,421,461 acres, at a cost of 1.627d. per acre, inclusive of the 4 per cent. interest charge upon the capital cost spread over 28 years, maintenance, and administration.

I have already referred to the circumstance that while speculation is practically eliminated from such a proved area as the Great Artesian Basin, yet there are times when the drillers are compelled to view their operations with anxiety, especially when they notch succeeding 1,000 feet marks with-

out drawing a bucketful of water. The contour of the water-bearing stratum is likely to be irregular and to be interrupted here and there by intervening walls of up-thrust rock, or "faults." Consequently, the possibility of disconcerting failure, even in the most attractive areas, must not be overlooked, although, as a rule, patience and perseverance will bring their reward.

The bore known as "Bimerah No. 3 Whitewood," lying between the Barcoo and Thomson rivers, in Queensland, is a case in point. Drilling was commenced and the tool carried down to 4,000 feet without showing a drop of water. Concluding that a serious fault had been struck the project was abandoned. At another point a party of drillers was confronted with a similar possible failure, but they stuck to their task, although the passage of the 3,500 feet mark was recorded without a sign of the precious liquid. The drillers, however, determined not to be beaten, descended lower and lower. As they were approaching the 4,000 feet level the characteristic signs of water were encountered. They buckled into their work with redoubled energy, and at last the water gushed forth with spirited energy. This success at 4,000 feet, when it seemed as if failure would have to be recorded, prompted the resumption of operations upon the abandoned Bimerah bore, with the resolution to drive down to more than 5,000 feet if necessary. At 5,000 feet the prospects were certainly encouraging, and at 5,045 feet the water was found. The flow, however, was only 70,000 gallons a day, an insignificant yield so far as spouting bores in Queensland go, but it represents the deepest well in the State. The readiness to carry a drill down for nearly a mile into the earth suffices to bring home the extreme value which is placed upon water in that part of the world.

Some of these Australian bores represent striking illustrations of applied science in an unfamiliar field. There is the "Claverton Downs Bore, No. 2," in Queensland, yielding water at the rate of 1,500,000 gallons every twenty-four hours from a depth of 1,777 feet. A more famous bore is the "Thurlagoona, No. 11," delivering 3,000,000 gallons of water a day at a temperature of 118 degrees Fahr. from a depth of 1,710 feet. Then there are the two bores on the Woolerina Sheep Run, which covers approximately 700,000 acres—over 1,000 square miles—and which, between them, furnish 5,000,000 gallons of water a day. This is led through shallow drains to various points for watering the stock.

The State of New South Wales can also point to some striking examples of artesian well-boring enterprise. There is the one at Boronga, in the county of Stapylton, where the tool had to be sunk to 4,338 feet, and which has an outflow of 992,943 gallons. This is the deepest well in the State, though it is run close in this respect by the Dolgelly bore in the same county, upon the Moree-Bogabilla road, where 577,930 gallons are drawn daily from a depth of 4,086 feet. Pride of place in regard to yield in this State is held by the New Yarrawa bore, which contributes 1,062,133 gallons a day from 3,590 feet.

But it is South Australia which holds the blue riband in point of depth. Of the 137 wells in operation at the end of 1916 four ranged from 3,000 to 4,000 feet, while two were in excess of the last-named figure. The deepest well then flowing was at Goyder's Lagoon, on the Hergoot to Birdsville Road, where the drills were carried down to 4,850 feet to tap 600,000 gallons a day. The State government then started a bore at Patchawarra, 35 miles north of Innamincka,

and drove the drill more than a mile into the earth's crust—5,453 feet. Water was struck at 4,000 feet, but only to the extent of 400 gallons a day—a mere trickle—so it was decided to persist in drilling until they notched the above-mentioned depth. There is every indication that in due course South Australia will be able to record the deepest artesian well in the world; that is, judging from contemporary indications. So far as this State is concerned, the richest well is at Coonie Creek, west of Lake Frome, where 1,250,000 gallons are obtained daily.

While rich strikes are only to be anticipated within the confines of the Great Artesian Basin, it would seem as if the north-west basin, in the State of Western Australia, is destined to produce some startling prize-packets. This is a relatively small basin compared with the more famous underground lake to the east. It extends along the coast, but embraces a very large tract of ideal sheep-raising country. The physical configuration, where water is relatively scarce, and where some perplexing watering problems have been successfully overcome, has led to advantage being taken of these water taps. The wells have been sunk, and the resultant yields are allowed to gravitate over and to supply an extensive area, to facilitate the raising of stock. Many remarkable flows have also been recorded, the most remarkable being one of 3,000,000 gallons daily from a bore which had to be driven only to a depth of 300 feet.

When the Commonwealth Government set out to build the transcontinental railway, linking the cities and their railway systems on the one side with the extensive steel networks in operation upon the other side of the continent, the negotiation of the desert was viewed with mixed feelings. The absence of water was held to constitute a very serious

rigorously controlled. Consequently, no more water than is actually required may be drawn off, while wastage is regarded as a crime. Drilling is carried out under both official and private auspices, and in a scientific systematic manner under the direction of trained engineers, the search for water having become as highly specialised a craft as the mining for coal or gold.

In New South Wales there is what is known as the Artesian Wells Act, which, passed in 1897, extends to the settlers in any district the right to petition the Government to sink a well and to distribute the water through approved channels. No settlers in any district need suffer from lack of water, or threat of famine. If they cannot agree to submit a unanimous request for the official provision of the bore, a two-thirds majority is sufficient to persuade the Government to satisfy the desire. In return for such State assistance the farmers must consent to transfer to the Crown a certain proportion of their land, not exceeding 40 acres, to provide the site for the bore and the other indispensable facilities, and also to assent to the imposition of what may be described as a tax contributing towards the cost of the work and the maintenance of the supply. This charge, however, cannot exceed 6 per cent. per annum on the total cost of the undertaking, nor must it represent more than the annual value of the benefit accruing to the farmer from the supply of the commodity.

While the State, however, is perfectly ready to assume responsibility for such operations, it by no means discourages private enterprise. As a matter of fact the latter is rather encouraged, as is shown from the fact that private bores outnumber the State possessions in this respect, roughly by 5 to 1. The Government appears rather to have

concentrated its efforts upon the provision of bores to secure watering facilities for flocks and herds passing along the various stock routes of the State, the movement of cattle being somewhat heavy. The daily contribution of water from the State-owned artesian wells is about 40,000,000 gallons, and their convenience has proved a distinct blessing to the sheep- and cattle-raisers.

As mining for water is rigidly controlled, so are the charges for providing watering facilities to passing herds and flocks. The Government leases the amenities, the rental, therefor, ranging from £1 to £235 per annum. The regulations controlling the issue of what are virtually termed licences are somewhat tightly drawn to secure the needs of the community, it being stipulated that the lessee shall reside constantly at the watering-place or provide a resident care-taker, the object, of course, being to ensure that passing stock shall receive refreshment at any time if it so desires. The tariff for watering is fixed, and ranges from 1d. per head for horses, cattle, and camels, to ¼d. per head for goats and pigs, and 1s. per 100 head or part thereof for sheep. But certain "free" watering facilities are provided, to which the farmers have unrestricted access and at all times.

While the majority of the watering stations and bore-holes are "spouters" or "gushers"—that is to say the water rushes out of its own volition—there are some instances where the rising water has to be assisted to the surface by pumping. Fortunately the pumping-stations are relatively few in number. Nature, apparently, is quite content to provide the power to ensure an adequate supply if man will only take the trouble to delve for it.

To the sheep-raisers and farmers of Australia the

puncturing of the Great Artesian Basin and other underground lakes in this manner has brought blessings untold. The discovery of this treasure imparted a huge stimulus to the meat and wool industry. Other countries, impressed by the far-reaching benefits accruing from the scientific utilisation of underground and imprisoned water supplies, as exemplified by Australia, are emulating the practice, to reclaim their own barren acres. This is particularly the case in the middle states of the North American continent.

East of the Rocky Mountains the vast plains feel the need of water sorely, especially during a hot summer. The water-carrying bed, of gigantic area, is from 500 to 1,000 feet below the surface, and the water cannot force its way to the surface because it is held down by a thick, dense blanket of shale. It cannot escape below because there is another layer of equally impermeable material beneath. So the water is held between the two, the thickness of the permeable sand being from 300 to 400 feet. Upon the Rocky Mountains edge the bed is bent upwards, and at the same time is elevated from 5,000 to 6,000 feet. The melting snows rush down the mountain slopes in the form of freshets and creeks, to tumble into the insatiable sponge of sand, to flow steadily downhill for hundreds of miles, though underneath the plains.

At the lowest points the water is several thousand feet below the level of the lofty slopes of the Rockies, where it commenced its subterranean journey. Consequently, if the dense, hard outer cover be penetrated by driving a drill through it, the water immediately gushes forth, and, despite the mechanical losses arising from friction through the pipe in its ascent, will fly into the air.

It was the discovery of this subterranean water supply which led to the exploitation of this source of energy and

precious liquid. The water is not only tapped to feed large areas of dry country which otherwise would be beyond cultivation during the torrid summer months, but is harnessed to drive machinery. At Niobrara, Nebraska, one artesian well not only furnishes water, but the pent-up energy contained therein is utilised to drive the electric plant wherewith light is furnished to the community, and also drives a flour-grinding mill.

So impetuous is the upward rush of the water that loose stones, caught in its embrace, are rattled upwards through the casing, which is generally 6-inches in diameter, at a merry pace. If these stones were permitted to complete their journey untrammelled they would wreak extensive injury to machinery, and so an ingenious device has been installed at the mouth of the pipe to catch them. It resembles a small boiler, being a steel cylinder placed just abaft the gate and valve, whereby the flow is controlled. The water falls into this stone-catcher, as it is called, and, as its velocity has been toned down by the regulator, any stones which have been hurried madly upwards are arrested in their flight, to drop harmlessly to the bottom of the vessel. To show the enormous force possessed by the water, one town which depends upon artesian bores for its energy and supplies has preserved a stone weighing 22½ lbs., which was flung up the pipe to enter the stone-catcher with a thud which was sufficiently convincing to notify the attendant that the trap had indeed made a lucky arrest. Had that stone got into the machinery harnessed to the bore it would have played widespread havoc.

The American plains not only imprison water in this manner, but natural gas thrown off by the vast petroleum deposits as well, and the occasional discovery of gas in the

water-bearing stratum has been responsible for some novel and interesting developments. At Pierre, North Dakota, wells which were sunk for water were found to yield sufficient gas to render the trapping of the last named profitable. The water is led to a tank where the gas, disassociating itself from the liquid, settles on the top of the latter. Thence it is drawn off to feed the gas-engine to which the electric generators are coupled for the supply of power and light, and is also utilised to supply the requisite power for the operation of a pumping-station.

As the American plains are essentially adapted to agriculture, water is mainly drawn from the gigantic reservoir lying far below the surface to provide the thirsty crops with copious draughts just at the very time of the year when they are in need of refreshment. Throughout the State of Nebraska may be seen extraordinary and quaint expressions of ingenuity for the raising of the water from open wells, and also contrivances for carrying out pumping operations, the wind for the most part being pressed into service to supply the requisite lifting energy. Many of these windmills are contrived from such materials as are readily forthcoming upon the remote farm, or from parts of abandoned agricultural implements. Such ingenious machines, involving a cost of only a few shillings, though highly effective in their work, contrast very vividly with the scientifically designed mills such as are to be seen in Great Britain, the cost of which ranges from £300 upwards.

The artesian well may be said to represent the most modern example of water-raising for irrigating purposes upon the plains; but while the majority of these bores are sunk for utilitarian reasons, others are driven to contribute

to the æsthetic amenities of American Ruralia. Thus we find shallow wells furnishing natural fountains in artificial parks, or supplying water for the maintenance of specially dug lakes and pools.

Even in the British Isles the artesian well is not a rarity, though it is so completely harnessed and controlled as to escape general observation. Gushers or open spouting bores are rarely, if ever, seen. Industrial plants, railway companies, large laundries, and other extensive organisations, needing tremendous quantities of water to pursue their operations satisfactorily, sink such wells so as to be independent of the public water supply, while, of course, the practice is economical because, after the bore has been driven and the water tapped, no further expense is incurred. Even the Houses of Parliament draw their supplies of water from an artesian bore, which has been sunk deeply into the water-bearing blanket underlying the metropolis.

In no country, however, has the prospecting and mining for this treasure of the earth been elevated to such an exacting science as in Australia, where it really constitutes the life-blood of the agricultural industry, more particularly in the inner territories. The diligence with which the work is prosecuted, and the scale upon which this craft is practised, have been responsible for the creation of a distinctive type of mining engineer. Seeing that the States of New South Wales and Queensland alone depend upon water from these bores to the extent of some 500,000,000 gallons a day, the reasons for specialisation in this direction are obvious. As the country becomes more densely settled and further stretches of the lesser known territories in the interior become opened up to the sheep- and cattle-raising industries, the demand for ample supplies of water will become more intense and, at the same

time, will compel the Government of the various States to become more and more systematic and scientific in their exploitation of this priceless treasure.

Only in this way will it be possible to ensure that full conservation of the natural resources which is so imperative, and which in turn will impose a more exacting demand upon skill and knowledge upon the part of those who desire to achieve triumphs in this province of activity.

CHAPTER III

Coal—The World's Premier Fuel

PRECISELY when the combustible properties of coal were first ascertained is a matter for lively speculation, while record is silent as to when it was first employed for stoking purposes. Wood being plentiful and readily obtainable, it constituted the obvious fuel among our woad-painted forefathers. It amply sufficed, because their needs were not exacting. Fires were mainly required to shed warmth, and for roasting the "bags" from the hunt, or for grilling the prizes from the traps set in the lakes and rivers. Although a certain degree of activity prevailed in the "commercial circles" of those days, such as the fabrication of native pottery and the fashioning of primitive metallic implements, the chances are that the domestic fire was utilised for such work, although, as events have since proved, the natives were by no means deficient in knowledge concerning fluxes and crudely contrived blast furnaces.

Doubtless the fuel qualities of coal were discovered purely by accident. It is easy to visualise the incident. Pieces of this commodity, detached from an irregular seam thrusting itself through the verdant sheath of a hill—an outcrop as it is called—became detached by wind and weather to tumble in the sheltered nook below. Along came the members of a tribe seeking an eligible residential site or camp to pitch their tent in the watered glade in the shadow of the hill. A bonfire

was promptly kindled upon the ground littered with fragments of the coal. Naturally these became ignited, to attract the curiosity of the ancients. To their unsophisticated minds the spectacle of burning stone, for such coal would have been considered by them, must have provoked amazement and intense speculation concerning the whys and wherefores. Doubtless it was put to cunning if not beneficial account by the medicine man and his contemporaries to assist in various weird rites, incantations, and machinations. But even the untutored savage is not so ignorant as the superior civilised individual would have us to believe. Once impressed with the fuel qualities of the black stone, it is only logical to assume that the observant aborigine did not omit to use it whenever opportunity offered, because it saved him the exertion of carrying wood. And in the course of time he undoubtedly did not hesitate to dig for it, confining his efforts, however, to open shallow workings at those places where the mineral thrust itself to the surface.

But, whenever and however coal came to be recognised as a fuel, the fact remains that to-day it is indispensable to the world at large. It is only within the past few years that its autocratic supremacy in this connection has been seriously challenged by another member of the family possessing all its characteristics, but recovered in a different form—to wit, petroleum. Yet coal has secured such a firm hold upon civilisation, enters into such a vast range of industry in one or another form, and withal is so liberally distributed over the surface of the earth, that years must necessarily pass before it suffers complete eclipse by its liquid rival. Certainly, at this moment, it is impossible for even the most imaginative and picturesque writer to paint a convincing word-picture of a coal-less Britain.

Nevertheless, in her distribution of coal, Nature has been somewhat discriminating. Great Britain, France, Belgium, Germany, the United States of America, Canada, Australasia, China, and South Africa are rich in coal. But many countries can point either to no, or only meagre, domestic reserves of this commodity. It is not to be found in Scandinavia nor in Italy, except to an insignificant degree, while several of the South American countries are as bare of supplies as is the Sahara Desert of cabbages. Such countries are compelled to import what they require to support their domestic industries, although they are becoming less dependent in this direction than they were, because they have turned their attention to the harnessing of water-falls to generate electricity, or have lighted upon unsuspected reservoirs of oil under their feet.

So far as we are concerned we have little to fear. In 1905 a Government Commission declared there were over 100,000,000,000 tons of coal awaiting exploitation in the United Kingdom, the whole of which was lying between the surface and a depth of 4,000 feet. The deposits in the United States are even more colossal, while, as might be expected, Canada really is made up of huge beds of coal which, so far, have been barely scratched. So that, notwithstanding the fact that the world is burning coal at the rate of 1,200,000,000 to 1,500,000,000 tons a year, we need not worry our heads unduly about a possible shortage or famine, although economists, perturbed by the grossly wasteful methods which obtain in the working of these reservoirs, are shaking their heads lugubriously and discussing the prospect of a coal-less world.

But no figures which have been advanced to show the coal reserves of any country should be accepted as gospel. In nearly every instance they are based upon calculations in

proved areas and only up to a certain depth—4,000 feet in this country. For instance, in the British figures cited above the coal beds of Kent are ignored, although investigations which have been conducted during recent years point conclusively to the fact that the Garden of England lies upon a gigantic foundation of coal, the extent of which has not yet been completely fathomed. Moreover, if we were to dive down to depths such as have been registered in France and Belgium, we should probably discover other seams, of which at present we know little or nothing. All things considered, we need not worry our heads for a few centuries to come over the prospect of an empty coal-cellar from the exhaustion of our coal supplies. The chances are not that our coal reserves will give out, but that this friend will be superseded by a rival, or that science will spring another surprise upon the world, completely revolutionising our knowledge, storage, and uses of heat.

I do not propose to discuss the story of the formation of coal. Every schoolboy and schoolgirl knows that what are coal seams to-day were dense forests thousands of years ago; that coal is merely tree trunks, leaves, bushes, and plants in an inert, severely compressed, rock-like form. Nature became frolicsome one day, gave a mighty shiver, turned the forests upside down, shifted hills, changed the coast-lines, diverted rivers, upset mountains, and pushed valleys upwards, covering what was a forest with an immense layer of sand, rock, and what not in the process. Under the weight and pressure applied, the green vegetation became converted into a lustrous black, rocky substance, to which we have applied the name coal. The composition of this rock is simple. It is essentially a composition of carbon, oxygen, nitrogen, and hydrogen, the gases being in a fixed form, effecting their

release and escape into the atmosphere when the coal is burned. But the foregoing elements are in association with sulphur, silica, and other incombustible materials which enter into the composition of the ash remaining in the grate upon the combustion of the coal.

The mineral is also found in many grades according to the length of its burial and the weight of, as well as pressure applied by, the strata superimposed. Peat is coal in the primitive stage. If Ireland could be turned upside down, burying the bogs from 2,000 to 4,000 feet, and they could be held down by a thick crust of rock, sand, and mud for a few thousand years, the peat would become converted into coal. Lignite is another form coinciding approximately with the half-way stage between peat and coal. Coal itself is divided into two broad classes, the one being known as bituminous and the other anthracite, and these are the grades for which mining activity is pursued. Bituminous coal is soft and brittle, rich in gas and other volatile constituents, and consequently is the grade most extensively sought to feed the furnaces of our factories and workshops, as well as distilleries where the gas is extracted, and domestic fire-grates. Anthracite is harder and denser, more closely resembling a metal. It carries the highest percentage of carbon and the lowest proportion of gas and other volatile constituents, the result being that it will not burn readily, or in the open grate, but requires the application of a draught of air to bring about combustion.

The circumstance that coal may be found anywhere below the 1,500 feet level—it is found in some places at a shallower depth—demands digging, or as it is called, mining, to recover it. Science has indicated precisely what methods should be practised to achieve this end. Fundamentally, one

principle obtains throughout the world. A shaft is sunk from the surface leading into the coal seam or measure, and once this is reached galleries are driven through the mass, the mineral being excavated during the advance and sent to the surface. In detail, however, the practice varies very widely, according to the rules and regulations which have been laid down by the governments of the various countries to ensure the safety of those who venture into the depths of the earth to keep the wheels of our factories turning.

Obviously, upon being resolved to exploit this treasure of the earth, it is necessary first to find your coal before you attempt to dig for it. Shaft-sinking is too expensive an enterprise to be assumed promiscuously on the off-chance of running across a seam. As one cannot peer into the interior of the earth to discover the whereabouts of the seams, or the directions in which they run, it is necessary, as a preliminary, to make a test. The cheese-taster bores into his product to draw a sample from the heart to determine quality. So with the earth. What are known as trial borings are made. Samples are drawn from varying depths to be closely examined to ascertain the character of the geological formation. In deciding the place to test the composition of the earth's crust for its coal the assistance of the geologist is sought, although he must not be accepted as an unimpeachable authority. He is not invested with supernatural eye-penetrating powers, but science has taught him how the crust should be built up, that is, assuming Nature has conducted her moulding operations along well ordered lines. He can say that coal *should* be found at such and such a place and at such and such a depth. Although the geologist does not claim to be infallible, he seldom errs. His deductions are only upset by the playful ways of Nature when she gives the strata forming the earth's

crust a strange twist, turn, or fold. Consequently no attempt should be made to venture for coal without his aid. Before the methodical, cold, calculating ways of science received recognition the divining-rod was the popular instrument wherewith searches for minerals were conducted; but this was sheer quackery. Yet, strange to say, this primitive idea is still regarded by superstitious miners as being more reliable than the so-called newfangled system of deliberate deduction in accordance with firmly established constitutional scientific laws.

Driving this trial bore is an undertaking in itself, and may prove exceedingly costly. Our old friends the Chinese, who were experts in this field while Europeans were chasing or fleeing from the ichthyosaurus and his contemporaries, elaborated a system which enabled them to drive holes 2,000 to 3,000 feet into the earth, possessing the virtues of being simple and effective. We accepted the Oriental method, but have improved it to an extraordinary degree. Although these modifications have exercised the effect of rendering the task more costly, they enable the work to be fulfilled more promptly and efficiently.

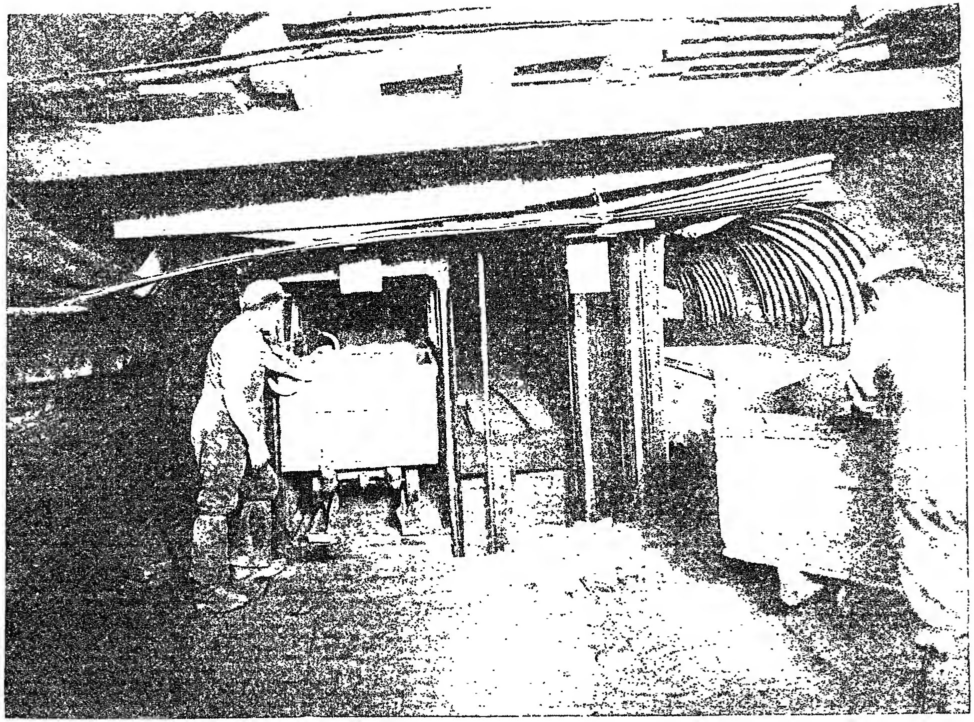
Drilling may be carried out by either of one of two methods, or by a combination of the two. The one is rotary, in which the drilling tool is twisted into the earth. The other is percussive, in which the tool is elevated a certain height, suddenly released and allowed to fall upon the desired spot, the force of the impact shattering the soil. The business end of the boring tool may be either a chisel bit or a cutter, the face of which is fitted with diamonds—not the scintillating gem with which we are so familiar, because such would be too expensive, but what is known as the black diamond, which is an exceedingly hard substance and somewhat tough,

although it, too, is relatively expensive. Under the rotary system advance is continuous, since progress must be recorded the whole time the instrument is being rotated; whereas under the percussive method it is intermittent, as the tool requires to be lifted after each stroke or fall. The bore-hole itself is of narrow diameter, and when the percussive practice is followed the chisel is given a slight turn for each successive stroke, so that the cutting edge may be brought to strike a fresh part of the surface of the rock.

If the straight, percussion system is continued throughout, it is open to a certain objection. The impact pulverises the soil, and upon striking the seam obviously shatters the coal as well, this being brought to the surface in a dust-like form. The fact that coal has been struck is obvious from the nature of the debris brought up, this being scrutinised closely during the operation, more especially when indications point to approach to the coal measure. While the quantity of coal brought up in this way may be noted, it is not easy to estimate the thickness of the seam being penetrated, although, of course, the diameter of the hole being known, it is possible, from the volume of the spoil recovered, to make a calculation. For purposes of accuracy the preferable practice is to withdraw the sample in the form of a core, after the manner of the sample of cheese withdrawn from the mass by the taster. The core being in the form of a thin, circular column, the depth of the seam, as well as the character and thickness of the interposed layers of rock, may be promptly read off. The core may be preserved, if desired, for further reference; while, if it be started at a certain depth and continued to the completion of the work, it is possible to present a continuous section of the earth's crust between those two levels.

Boring does not cease with the striking of the actual mineral. The coal measure, as it is called, in reality comprises a succession of alternating coal seams and layers of rock. The depth of the measure is from the surface of the topmost, to the base of the lowest, seam, and this thickness varies very widely. One might compare a coal measure with this book. If laid on its side and turned over page by page an illustration will be found at irregular intervals, with pages of text between. The illustrated pages might be said to coincide with the coal seams, while the text pages represent the intervening layers of rock. In an actual boring in the Kent coalfields coal was struck at 1,437 feet, and drilling was continued down to 2,276 feet. In the course of this 739 feet thirteen successive seams of coal were struck, aggregating in thickness 40 feet 11 inches, so that practically 700 feet was represented by the intermediate rock layers. The thickness of the coal seam ranged from 18 inches to 75 inches, while that of the intervening rock varied from 6 feet to 223 feet. It will thus be seen how necessary it really is to carry the actual boring to an adequate depth. As a rule seams of less than 24 inches are not worked; under contemporary conditions it does not pay to do this. On this assumption only seven out of the thirteen seams penetrated in the boring to which reference has been made would pay to work, and it was not until a depth of 1,948 feet had been reached, and the drilling tool had passed through seven seams, that the first most promising strike was made. At this depth the boring tool entered a seam 75 inches in thickness, actually the thickest discovered, although at lower levels two other seams of 72 and 73 inches respectively were found.

To a certain degree coal-boring is speculative. Seams may be struck, but the coal may fail to be of uniform quality.



COAL MINING

Down at the foot of the shaft, showing a "tram" in the cage.

it is likely to vary, not only from seam to seam, but even in the seam itself. The uppermost part of the seam may be of poor quality and suffer rejection by the miner. Similarly what appears to be an excellent seam, as revealed by the boring tool, may prove to be freely broken up with layers of shale, which likewise have to be discarded. The drilling tool, in its descent, may have missed this bad section, even only by an inch or two, and thus given quite an erroneous record of the actual seam. There is also the chance that the seam may be relatively short; it may become attenuated and die away into the rock but a few feet to one side of the boring, or become split up into several thin layers with intervening sections of rock, similar to that interposed between the main seams. Consequently, although the boring suffices to prove the coalfield, it affords no means of judging its area or uniformity. Of course, in the case of proved fields, such as those of Yorkshire, Lancashire, Scotland, and Wales, the general lay-out of the coal beneath is known, and one boring may suffice when embarking upon an extension of the area to be mined.

In the case of a new field, the character of which is completely unknown or doubtful, a single boring is insufficient. It is necessary to embark upon what might be called a comprehensive plan of exploration, and to carry out a series of trial borings at different points according to the recommendations of the geologist. The first boring might be sunk approximately in the centre of the field, in which event similar work will be continued at varying distances from that centre, the tests being pushed gradually outwards until the edge of the field be reached, if such be possible. This is the work which proves so expensive, and which also occupies a considerable length of time. Years may pass in proving

thoroughly a new field. The results of each boring are carefully perused, and from this accumulated evidence, what might be described as an underground coal map is prepared, showing not only the possible area of the field, but the variations or continuation of the respective seams. It was this work which delayed the opening up of the Kentish coalfields for so many years, and which incidentally swallowed up so much money.

Those preliminary operations are known as prospecting for coal, and they serve to confirm the deductions of the scientist concerning the geological formation in the territory investigated. From the mass of detail yielded by the drilling tools the engineer is able to complete his part of the work. He will be able to estimate the approximate cost of sinking the shafts, and to set forth some idea of the cost of working the mine, together with its probable output. He will also be in a position to advance some idea of the inclination or dip of the seams running from his shafts, as well as the possible existence of faults and what they may mean to the ensuing enterprise. Of course, here again he bases his calculations upon the maintenance of normal conditions. They are liable to be upset by the interposition of some contingency which the trial borings have failed to reveal.

In mining, as in every other engineering enterprise, the unexpected has an awkward knack of turning up. In one instance, the sinking of the first shaft upon a new coalfield struck an unsuspected pocket of running sand. The drilling tool, in making the boring, had missed this obstacle by only a few inches. In sinking his shaft the engineer ran right into it. Progress was delayed for several months, and many thousand pounds were expended in grappling with this formidable enemy. As events proved, this pocket was relatively

small, because, when another shaft was sunk but a short distance away, dense rock was encountered at the level where the engineer had half expected to meet the sand once more, and in anticipation of which he had elaborated full precautions.

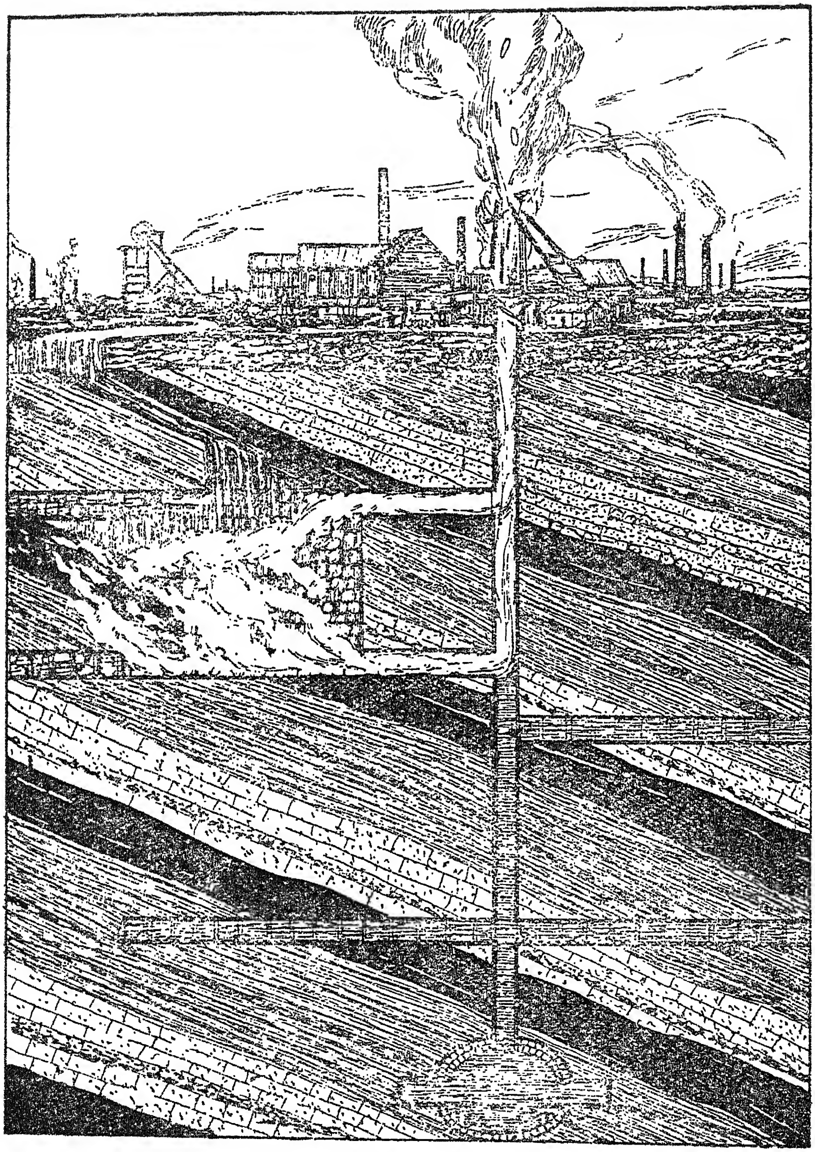
Shaft-sinking represents the most expensive individual part of the whole undertaking, especially when a great depth is involved. It eats into the capital provided for the purpose to an amazing degree and with astonishing rapidity. In so far as this country is concerned, legislation demands that at least two shafts shall be sunk to each mine, and that they shall not be spaced less than 45 feet apart, while a passage with a minimum opening of four feet connects the lower ends. The one shaft known as the "downcast" constitutes the working shaft, being that through which the miners are borne to and from their work and also that through which the coal is moved. The other is called the "upcast," and although it has to be equipped with winding gear such as that installed at the head of the "downcast" shaft, it is usually reserved for ventilating purposes, as well as the removal of water from the mine.

In this country the shaft is generally circular in section, this design being preferred for technical reasons. It ensures the maximum of strength and at the same time facilitates lining, especially when the general practice is to line the shaft with brick or iron. In the United States, however, a rectangular shaft is often preferred, but this tendency is governed by the principle of lining the shaft with timber, which, as a rule, is cheaper and more readily procurable than brick or iron. Still, even in that country, more particularly in the settled areas, there is a disposition to adopt the British circular shaft. In elaborating his ideas, the engineer has to determine the diameter of the shaft, and this is governed by

the depth to which it is to be carried, as well as the amount of coal which is likely to be mined and handled during the day, but modern practice inclines towards a shaft ranging from 16 to 21 feet in diameter.

Shaft-sinking might be likened broadly to tunnel building, only with the tunnel slanting on end. Many of the dangers and difficulties incidental to the latter are encountered in the former, and many of the self-same artifices and precautionary methods are introduced. The top soil is excavated as an open working in the usual manner down to solid rock, with due precautions for the safety of the excavators. At first a temporary lining is provided, comprising iron rings or plates suspended from the top, with wooden planks driven in behind the metal work. When the hard rock is reached the permanent lining is taken in hand. Segments of iron are lowered to the bottom to be built into a crib. When this is completed the brickwork or permanent metal lining is built upon this and carried to the top. Sinking is resumed, and at a predetermined level a second crib is built, and this in turn serves as a foundation for another section of lining, which is continued upwards until it reaches the crib already in position. Thus the lining is completed in vertical sections.

The bugbear of the shaft-sinking engineer, as with the tunnel-builder, is water. It is almost certain to be encountered, though with varying severity. Quicksand is another foe to be dreaded. To cope with the water it is necessary to utilise a pump, because in this instance the water must be lifted to the surface. Special pumps have been designed for this service, some of which are of impressive proportions in regard to length. They are suspended from the gear erected over the shaft, flexible connection in the form of wire ropes or chains being essential to allow the pump to descend con-



Section through a Coal Mine Showing the Workings

temporaneously with the progress in sinking, the water being forced to the surface through suitable flexible armoured hose of adequate diameter.

When water is encountered it is necessary to carry out lining operations along special lines known as "tubbing." A special crib or curb is fashioned, and upon this is built an iron instead of the usual brick lining. Tubbing comprises a number of cast-iron plates, segments, or rings, which are really shallow boxes of special design, the sides of which are bracketed to the front. Each plate is provided with a central hole to permit the water to escape until the tubbing is completed, the engineer preferring to allow his enemy to have full rein until the critical moment. After the plates have been placed in position the space between the rear face of the tubbing and the natural side of the shaft is grouted—the whole of the space between the two is charged with cement in precisely the same way as the space between the segments forming the tunnels of our tubes, and the soil through which the excavating shield has been driven, is filled in. The cement, when it has set and hardened, forms a continuous shield or wall as hard as rock, effectively sealing the water.

As may be imagined, tubbing is a slow, costly and difficult operation withal, while it does not always solve the problem. One of our collieries situate on the north-east coast decided to make an attempt to win the coal from a seam which dived under the North Sea. To do so involved following the wandering seam. But when it came to sinking the shaft the rock which was being penetrated was found to hold water like a sponge and appeared to be about as insatiable. Immensely powerful pumps, capable of lifting 11,000 gallons of water every minute, were brought into action, but they could do no

more than just hold the foe in check. The moment they ceased work the water gained the upper hand. So heavy was the inrush that the water would rise in the shaft at the rate of six feet a minute when pumping was suspended.

The tubbing practice generally followed proved quite out of the question, and so the system elaborated by an eminent Belgian engineer years before, and which had proved strikingly successful, was introduced. This method was especially contrived to cope with such emergencies as this. It comprises a tool known as a *trépan,* which drives a small hole from three to five feet in diameter. This is then opened out by a larger tool, followed in turn by another *trépan,* which enlarges the hole still further until at last the full size of the shaft is reached. The tool itself consists of a number of chisels set in a frame made of wrought iron, and which is suspended by wooden rods from the surface. It is weighty, the *trépan* for driving the first hole weighing from 6 to 8 tons, while that which excavates the hole to the full diameter may weigh from 20 to 30 tons. With this device the hole is driven to a certain depth and enlarged, the débris being cleared out as the work proceeds. Upon reaching a point where a water-tight joint can be made, special tubbing, comprising rings about 4 feet in height and cast in one piece, is lowered into the shaft, the bottom ring being furnished with a sliding ring or case carrying a quantity of moss, which, when pressed down by the superimposed weight, forms a water-tight joint allowing the tubbing to be completed. A horizontal diaphragm is placed near the bottom of the lining, having an opening in the centre, from which a tube passes to the top of the shaft. This pipe is introduced to carry off the water, the movement of which can be controlled. When free escape is permitted to the water

the whole lining sinks the diaphragm, really acting like a piston, the diameter of which is equal to that of the shaft, which may be likened to the cylinder. As the diaphragm sinks and the tubbing is completed, cement grouting is carried out, as previously explained, to form the rock-like jacket between the tubbing and the natural soil-wall of the shaft. It will be seen that the apparatus is really self-acting, and reduces the risk to human life. It completely solved the above-mentioned problem of tapping the coal seam running under the North Sea, and has proved eminently successful in its applications upon the Continent.

Quicksand constitutes an enemy of quite a different order. Piling is freely resorted to in this instance, wooden planks being utilised for the purpose, but this is not always a feasible solution to the problem. The soil being penetrated often is too treacherous to submit to simple treatment. Consequently recourse is made to a novel expedient whereby an artificial solidity is imparted to the soil to allow the shaft to be driven through the unstable reaches. The "bad patch" is frozen. The process is somewhat elaborate. A circle is marked off round the shaft, and holes are driven into the ground to the depth required along the line of this circle, care being observed to space them equidistantly. In one instance in the north of England where it was found necessary to adopt the freezing process the holes had to be driven down to a depth of 484 feet, the driving of each hole, of which there were twenty-eight, occupying twenty-four days. A freezing-tube was lowered into each of these holes, and connected up to the brine-circulation system. The freezing-plant comprised two steam engines and four ammonia compressors. The brine, comprising a solution of 26 per cent. of chloride of magnesia at a temperature of 17 degrees centigrade, to

extract the heat from the treacherous stratum and to convert it to a frozen condition, was pumped from the freezing-plant through the tubes driven into the ground and then back to the freezers, where the heat it had picked up was dissipated, and the cooled brine dispatched upon another journey through the closed circuit.

So completely was the ground frozen that explosives had to be used to drive the path for the shaft-sinking equipment. In making the shot-holes every care had to be exercised to prevent them from becoming frozen. The efficiency of the process was revealed very strikingly when pockets of water were reached. These were found to be solid masses of ice. While sinking was a relatively slow process, progress proceeding on a very few feet per week, it was completely successful. The intensity of the freezing was brought home very convincingly because the treacherous running sand was converted into a material resembling hard freestone. When the treacherous spot had been safely negotiated a steam pipe was introduced into the freezing circuit. This warmed the brine, which radiated its heat through the frozen ground during its passage. In this manner the soil was gradually thawed. The restoration of the natural condition of the sand completed, the freezing-tubes were withdrawn, the holes filled with gravel, and the mouths sealed with concrete.

During recent years, and owing to the perfection of machinery, the depth to which the shaft is taken has gradually increased. In this country the limit so far recorded is about 3,000 feet, but this does not represent the limit to which the work may be conducted, since in the copper mines of America the depth ranges up to 3,500 and 4,000 feet. When the shaft has been carried to the designed depth and communication with its fellow has been established a strong

chamber is made at the bottom of each, forming what is called the porch. This must necessarily be of substantial design, owing to the immense weight which it is called upon to support, while further protection is left to the shaft by allowing pillars of solid coal to remain.

At the head of the shaft is erected the truncated pyramid building with which we are all familiar. Here are mounted the large pulleys, over which pass the ropes extending from the adjacent house carrying the winding engines, and by means of which the cage carrying the miners as well as the coal is operated.

From the base of the shaft galleries are carved through the seams bearing the coal, and in course of time these underground passages become an intricate network, while the working face, the point whence the coal is excavated, may be a mile or more from the bottom of the shaft. An established coalmine, one which has been persistently worked for years, may be compared to a houseless town, owing to the bewildering intricacy of its galleries and cross-cuts, which to the uninitiated appear to have been driven without rhyme or reason, but which, nevertheless, have been cut according to a carefully prepared plan. In some instances the base of the shaft is regarded as the starting-point, the miners hewing the coal and pushing their way outwards according to the lay of the seams. In other instances a narrow passage is driven to a distant point, and then is worked backwards from that point to the shaft.

One method of working is known under various names, depending upon the locality. Thus in some places it is known as the "post-and-stall"; in others the "pillar-and-stall"; in a third area the "bord-and-pillar"; while in Scotland it is described as the "post-and-stoom" system. But whatever

the description appellative, the method is the same. Roads are driven through the coal with cross-cuts or lateral connecting passages at intervals, columns or pillars of coal being left to support the roof. At a later date, when excavation has been carried to a certain predetermined point, the pillars sustaining the roof are cut away, being replaced by timbering.

A second is known as the "long-wall" method, and in this case in pushing out from the bottom of the shaft the whole of the coal is removed, a gradually increasing face thus being formed. A variation of the "long-wall" method is that known as the "long-wall-working-back" system, in which the road is driven from the bottom of the shaft to the outermost point to act as a channel of communication. Having reached the limit of penetration the coal-face is widened out to the full extent of the seam, and the miners then work back towards the shaft, removing the whole of the coal as they do so. Local conditions, fancies, and the predisposition of the technical staff govern the selection of the system to a pronounced degree, although it is generally conceded that the "long-wall" method, when carried out along well laid lines, is the more economical as well as being advantageous from other points of view, such as facility of ventilation and less liability to accident from falls. On the other hand, the "long-wall" method is likely to precipitate subsidences which become communicated to the surface. The earth caves in as the coal is excavated. Should there be any buildings above, these suffer somewhat severely, as may be readily conceived.

But the roof of a gallery in a colliery, as in a sewer driven just below the surface of the ground, is liable to collapse. Faults and weaknesses in the rock are certain to exist, and should these bad places be allowed to prevail unprotected, disaster is wellnigh inevitable. Accordingly, to reduce the

possibility of such accidents to the minimum the workings are safeguarded with timbering to reinforce both sides and roof of the gallery. In the modern mine the consumption of timber in the form of pit-props is astonishing, and for our supplies of this we are virtually dependent upon foreign sources. In normal times our annual importation of pit-props or pit wood to shore up the roads of underground Britain as represented by our collieries, runs into about 3,500,000 loads, for which we pay something like £4,500,000. The timbering is carried out along distinctly ingenious lines, activity in this field having led to a manifestation of a design which is peculiar to our subterranean hives of industry.

All coal, with the exception of anthracite, which is very dense and hard, has lines of cleavage along which splitting can be carried out without undue effort. Some of the roads are driven in the direction of these planes, while others cut across them. The former are known as "ends," while the latter are styled "bords," and the coal can be worked far easier from the "bords" than from the "ends." The actual removal of coal is generally accomplished by what is called undercutting. The miner attacks the solid mass of coal forming the face at the bottom, cutting and picking his way to a depth of 6 feet or more. Thus the block is really undermined, and to prevent the mass collapsing and burying the workers the face is supported by timber or "sprags." When the undercut has been completed, if the coal be of the soft variety the mass may be detached by means of wedges driven in the face near the roof, the supports or sprags meanwhile having been removed. As a rule this simple expedient suffices to bring the block down with a run, and it suffers disintegration in its fall. But if the coal be hard the gentle persuasion possessed by explosives has to be exerted. In this

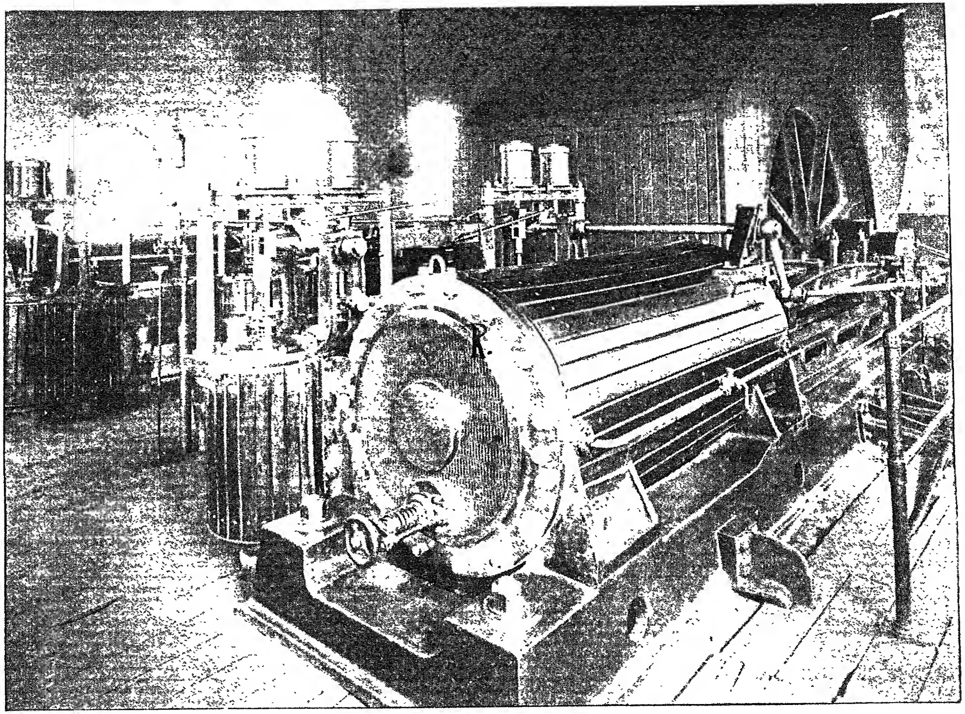
event the selection of the demolishing agent has to be conducted with extreme care according as to whether the mine be fiery or otherwise. If dangerous, explosives which are stated to belong to the flameless variety must be used, otherwise the dangerous and readily combustible gases present will become ignited to precipitate disaster.

As may be imagined, the task of holing a wall of coal is decidedly arduous, often necessitating the miner assuming an extremely cramped and exhausting position to wield his tools. This is especially the case when the seam is thin. He will often be compelled to lie upon his back or to assume a crouching position to ply his pick. In order to reduce this demand upon physical staying power and strength to the minimum ingenious mechanical coal-cutting devices have been evolved, actuated either by electricity or compressed air. There are two broadly defined classes of mechanical cutters, the one working somewhat upon the lines of a saw, the cutters being disposed upon the periphery of a rotating disc, or a travelling pitch chain, and thus cutting into the coal in their travel. The second is really an ingenious application of the percussive drill, sharp blows being delivered in rapid succession to the coal face with a long chisel-like pick. But whatever method be adopted the result achieved is the same—the holing of the block to facilitate its fall. So far as this country is concerned the mechanical coal-cutter is utilised only to a small extent, whereas in the United States it is most extensively employed. Its advantages are many. It relieves the miner of the most exhausting duty; accomplishes the work in far shorter time; is more economical, because the percentage of small coal is reduced thereby; while it is safer, because it minimises the risk of the roof collapsing.

When the coal has been broken down it is transferred to

tubs, which are moved to the bottom of the shaft, either by mechanical means, or by the aid of ponies. The pit pony is the member of the brute creation entitled to our unqualified commiseration. Once he enters the pit he is condemned to a life underground. Unlike the miner, he does not secure a breath of fresh air or a sight of the green fields in the course of a few hours, but is moved to his underground stall. His whole life is passed, with few if any spells of relief, in the darkness and silence of the mines. Humanitarianism has sought to render such employment of animals unnecessary; busy brains have been, and still are, at work endeavouring to secure his complete banishment from such a depressing environment. In the modern mine the pony is virtually a stranger. The workings are planned in such a manner as to permit the employment of power systems of haulage which are quicker, cheaper and more satisfactory. In those instances where the workings incline from the bottom of the shaft, this being the lowest point in the mine, gravitation is the force employed. The laden wagons, or tubs, run downhill, and in so doing hoist the returning empty vehicles to the top of the incline or the working face. If a single line only be possible and a "turn-out" cannot be provided at the halfway point to permit the two tubs travelling in opposite directions to pass, then the tub is connected to one end, and a balance weight running between the rails at the other end of the rope, this weight being drawn up by the descending full tub, and pulling up an empty vehicle in its descent.

If the situation be reversed, the bottom of the shaft being at the top of the incline, the full tub or train of laden tubs is hauled up by a winding engine, the empty vehicles being allowed to run back by gravity. Where the conditions are fairly level the vehicles are moved by an endless rope,



KEEPING A COAL MINE PURE

Winding, ventilating and pumping machinery at a colliery

which is constantly travelling, the tubs being attached thereto by means of a clip or gripper, after the manner of cable trams, to be hauled to the desired point, or else by what is known as the "main-and-tail rope" system is employed. In this case the train and rope form a continuous band, the main rope being attached to the front of the train, while the tail-rope, passing from the engine and round a pulley at the extreme end of the workings, is brought back and made fast to the tail end of the train. The main rope pulls the load to the bottom of the shaft and the tail rope drags it back again to the loading point. In some instances, notably certain shallow mines, electric locomotives and quaint engines working with petroleum motors are employed for tractive purposes, the mines in these instances having a complete railway network passing through the intricate lay-out of streets.

Reaching the bottom of the shaft, the tubs are run into the cage, which has a series of decks, each capable of receiving a certain number of tubs. When laden the winding engine is set going, and the cage is elevated to the surface, where the tubs are run off to tippers, into which they shoot their contents. The coal falls on to screens or sieves of varying mesh, the smaller pieces falling through according to the mesh which will pass them, and thus becomes sorted or graded. It is then discharged on to a conveyer belt to undergo a further sorting, this time according to quality. This task is performed by hand, which will explain what is meant by hand-picked coal, indicating that the coal has not necessarily been brought down in the mine by a hand-wielded pick as might be imagined, but has been manually sorted after reaching the surface. If the coal be dirty, that is associated with deleterious material, as is the case in certain Continental

coal-mining districts, it is submitted to a washing process, which removes the whole or greater part of the impurities, and is then led to the waiting railway vehicles to be moved to various parts of the country.

Mining for coal sounds a simple, straightforward task, as indeed it is when conducted under ultra-modern methods, where liberal recognition is extended to inventive brilliancy in the adoption of mechanical devices. Activity in this field, as in every other branch of endeavour, has been pursued to one end—to reduce the strain upon the human factor as represented by the miner. Thousands of pounds are sunk in the literal as well as metaphorical sense in a new mine, but the capital expended upon the actual sinking of the shaft and opening up of the seams is but a fraction of that which has to be poured out in the acquisition of an efficient underground tramway network, timber for securing safety to life and limb, coal-cutters, wonderful engines for efficiently ventilating the whole of the workings, pumping-engines to keep down the water and to release the men from the necessity to toil, perhaps, ankle-deep in slush and slime, electric lighting installation, elaborate and wonderful plant, comprising grading, topping, and sorting appliances at the surface. Sinking the actual shaft may be heavy, but it represents virtually the first and last cost. Maintenance charges are far heavier, while a sharp eye and a close hand have to be maintained upon inventive progress, since every proved device represents a further step towards higher efficiency, and, should the miner keep pace with development, an increased output of this indispensable commodity.

CHAPTER IV

Treasure Trove from the Volcano

SULPHUR might very appropriately be described as "the wonderful one-hoss shay" of industry, because it is difficult to mention a field of activity in which it does not play a more or less prominent part. Yet it was not so many years ago that this element was regarded, not as an industrial handmaid but as a prophylactic and fumigating agent. Associated with treacle it was declared to be capable of curing all the ills to which flesh is heir, and even to this day there are many who will vehemently maintain that the hoary household remedy, brimstone and treacle, is more effective than all the rest of the contents of the British pharmacopœia put together. It was also invested with extraordinary disinfecting powers, which possibly is not surprising. Parasites able to thrive in an atmosphere of sulphur dioxide, the suffocating fumes thrown off by burning sulphur, must indeed be endowed with wonderful tenacity of life.

To-day flower of sulphur is called upon to fulfil far more vital missions in the scheme of things. How would industry roll along without its sulphuric acid, which represents sulphur in an unfamiliar guise perhaps, but cannot be equalled for its specific and multifarious uses! Indeed, we should find it extremely difficult to keep going without our familiar, though possibly disdained, yellow non-metallic element.

Fortunately for the busy manufacturing world at large,

sulphur is fairly widely distributed, though being a product of the furnaces raging in the interior of this sphere, it is only to be found in a virgin state in those countries where volcanic activity either prevails, or has been manifest, for the simple reason that the burning mountain constitutes the natural outlet for the delivery of the material from the gigantic furnaces toiling night and day beneath our feet. In Britain, and other similarly situated countries, the sulphur is found only in association with other substances in the form of pyrites, which have to be subjected to distinctive treatment to release the sulphur content, but in many instances the sulphur is poor in quality and low in yield, and is most extensively employed for the production of sulphuric acid.

For this reason commerce depends rather upon those countries, such as Sicily, Iceland, and Japan, where the sulphur is to be found after the manner of coal. During recent years the United States of America have entered the market with a native product, which is secured by a highly ingenious method, to which I refer later. For many years—even to-day—Sicily has constituted the main source of supply. The sulphur is for the most part extracted from a section of territory ranging from 90 to 105 miles in length by 50 to 56 miles in width, and affords employment to approximately 350,000 miners drawn from the ignorant peasant class.

The distribution of the sulphur is somewhat peculiar. It is not found in seams like coal, but rather in isolated beds or pockets among the argillaceous limestone, bituminous marl and gypsum. These pockets vary widely in area and thickness, but the beds of sulphur-bearing rock are generally fairly extensive, and so are profitable to exploit.

Precisely when the Sicilian industry was first started is not known, but we do know that the Romans exploited this

treasure of the earth. Indeed, the industry is so extremely conservative that the methods introduced by the long since departed Empire still obtain. There is an unfathomable opposition to the introduction of modern methods, notwithstanding the severe competition which prevails to-day in the commercial world, and this attitude has reacted severely against the continued prosperity of the Sicilian industry.

The crude and simple methods which obtain contrast vividly with the super-scientific practices which prevail in the modern world of industry. To visit the Sicilian sulphur mines is to step back some two thousand years, or to venture to another planet. The sulphur has to be mined, though it is not necessary to descend to such depths as prevail in the coal-mine, because the beds lie relatively near the surface. But as the topmost layers become exhausted the miners have to burrow deeper for their treasure, and the country in which the craft is practised has been honeycombed by tortuous passages and galleries. The mine is entered by steps hewn out of the solid rock, and to-day it is necessary to descend to a depth of about 600 feet to gain the main workings. From this point the workings ramify in all directions in a bewildering manner.

The sulphur is hauled out, and, being impure, associated with the marl and limestone, has to be subjected to a primitive smelting or burning treatment. For this purpose beehive ovens of the most crude description are utilised. It is a fortunate circumstance that sulphur has a low melting point—115 degrees centigrade—otherwise one would find it difficult to see how the process could be made profitable. As the sulphur runs it is drawn off to flow into moulds. When charged they are moved to one side to cool. After solidifying, the sulphur, in the form of cakes, is turned out of the moulds

and stacked, to be subsequently shipped either in the block or rock form, or broken into small pieces.

During recent years competition has compelled the adoption of methods more in keeping with contemporary practice. Superheated steam under pressure is driven into the layers of sulphur, and in this way the sulphur is melted, to be drawn off into moulds, no mining in the generally accepted sense of the word being necessary. Contrasting vividly with this attempt towards modernity is the extremely antiquated method which is still practised to a certain degree. The excavated material—sulphur, lime and gypsum—is piled in a heap, and is then fired somewhat after the manner practised in burning ballast, coal-dust and coke breeze being associated with the ore to facilitate combustion. In this manner the sulphur is melted, to trickle to the base of the mound, where it gathers. When the fire has died out the pile is left to cool. Subsequently the mound is demolished, and in the centre is found a solid core of sulphur.

Previous to 1906 the exploitation of the sulphur was conducted along individual lines. There were about 180 producers operating some 484 mines on the island, and they competed against one another in the disposal of their product. Such tactics led to hazardous speculation, while often the product was sold at ruinous rates—even at a dead loss. The industry was in danger of collapsing completely. Then the Italian Government stepped in and compelled all the producers to combine to form a trust. This community of interests was to be concerned exclusively with the mining of the product; it was to have nothing whatever to do with its sale. The Government would attend to this side of the issue, and the producers were compelled to hand over the whole of their output to the State.

One outcome of this official action was to bring about the closing of 120 mines out of the total of 484 then being worked. But it was only the smaller and unremunerative mines which suffered such extinction, though even their abandonment caused a certain amount of unemployment. The issue resolved itself somewhat satisfactorily because the greater proportion of the disbanded labour promptly emigrated to other countries, where the outlook was so much more attractive. State action steadied the market and the native industry, as well as providing the means for meeting the American competition which had just commenced to make itself felt in no uncertain manner. In 1860 the export of sulphur from Sicily was 112,000 tons for the year. In 1881 it rose to 390,000 tons. High-water mark was reached in 1905 with 570,000 tons, which suffices to prove that the world's consumption of sulphur is really heavier than might be imagined. But when the American competition became fully experienced a wave of extreme alarm swept over the island, particularly when the Italian Government found itself being undersold in the European market. A conference was promptly sought with the American interests with the object of mitigating the effects certain to arise from such rivalry. The Italian authorities emphasised the misery and discontent which would be certain to arise among the unsophisticated Sicilian peasants upon the closing of the mines, which would be inevitable were the American company to push its activities to their logical conclusion. The subject was discussed amicably, and a zone of trading was established, the American company undertaking to refrain from seeking further footing in Europe on the Italian Government agreeing to abandon its American market. This was a heavy blow to the Sicilian interests, because the United States had been an attractive source of

trading, but the suggestion had to be accepted. Forthwith the output decreased to about 400,000 tons in 1909, but probably recorded a spirited revival as a result of the European war, which was accompanied by a heavier demand for sulphur for the manufacture of munitions.

The story of how the Americans entered the sulphur industry constitutes a fascinating romance, and offers a striking tribute to brilliancy of inventive ingenuity. The State of Louisiana meets the waters of the Gulf of Mexico in a low-lying plateau which is known as the coastal plain. Oil was discovered in this territory, and it was not long before the petroleum industry became established; but in drilling the wells the engineers encountered an immense alluvial deposit of sulphur in the form of a volcanic cone. Standing in an upright position, the apex came within about 800 feet of the surface of the earth.

This discovery created a sensation which was additionally remarkable because the deposit had never been suspected. Here was the opportunity to establish a new American industry and to render the country independent of Europe in regard to the supply of an essential commodity for industry. Extraordinary stories and figures concerning the extent of the deposit reached Europe, and the Italian Government, apprehensive of the outlook for the Sicilian industry, promptly dispatched an engineer to Louisiana to conduct independent investigation, and to refute or confirm the stories which had flashed round the world.

The outcome of the expert's visit was scarcely of a nature to allay Italian uneasiness. It accentuated the feelings of apprehension very pronouncedly, because the engineer declared that the American deposit which he had examined —proved up to that time—represented no less than 40,000,000

tons of sulphur of the highest grade, which would be adequate to meet the entire world's demand for this article for many decades to come.

This was not the most disturbing factor, overwhelming though it was. The engineer explained that, owing to the extremely ingenious means adopted for mining the mineral—one which was quite in accordance with American time- and labour-saving methods—the outlook for the Italian industry was exceedingly ominous. Whereas sulphur was costing 50s. a ton to mine in Sicily, the Americans were producing it for 15s. a ton. This meant that the American company would be able to sell its product in all the markets of the world at a figure below the actual cost of production in Italy, and then show a handsome profit. Needless to say, the description of the American method created consternation because it was realised to be eminently practicable, conducing to the minimum of waste and capable of yielding a product of virtually 100 per cent. purity. Indeed, the American company was guaranteeing the sulphur which it sold to be of 99½ per cent. purity, and this was below the actual figure, though higher than the rival product derived from Sicily.

It would be difficult to contrive a simpler or more inexpensive method of mining sulphur from a depth of 1,000 and more feet than is practised in Louisiana. The sulphur is not mined by the aid of pick and shovel, but is pumped in the free pure condition to the surface. The method by which this is achieved is distinctly novel and wonderfully effective.

The discovery of sulphur was communicated to Dr. Herman Frasch, the eminent oil authority. Years before, while residing in Canada, this chemist had wrestled with the problem of desulphurising the petroleum found in Canada

with complete success, thereby transforming a useless product into one of the highest value. Being actively associated with the Louisiana enterprise, he immediately turned his thoughts to the exploitation of the new sulphur deposit. Digging for the mineral in the characteristic manner appeared to be the only feasible means of bringing it to the surface, but after reflecting for a while the presiding genius turned to his colleagues and remarked: "We won't mine it; we'll pump it to the surface!"

Frasch was accepted as a genius, but how he could possibly evolve a means of bringing up a solid rock from a depth of 1,000 feet by means of pumps baffled his colleagues. Observing their looks of incredulity and wonder as to whether genius had not assumed a strange kink, he went on to explain.

"Look here! Sulphur melts at 115 degrees centigrade. Now if we liquefy that sulphur and keep it fluid we can pump it to the surface as easily as we can pump petroleum. All that is necessary is to drive water heated to a certain temperature into the ground under pressure."

When he explained how he intended to carry out his proposal, all feelings of doubt which had crept into the minds of his colleagues vanished, and they at once realised that a new American industry was to be established upon novel, solid lines—one which could give them complete control of the world's markets. Forthwith the task of sinking the first and experimental well was taken in hand with spirited energy and enthusiasm.

When the bore-hole had been driven well into the cone of sulphur, water, superheated to 350 degrees Fahrenheit, was forced into the mass in columns, under a pressure of 100 lbs. per square inch. The sulphur melted readily, and, what was

more significant, disassociated itself from all impurities with which it was combined. The hot, liquefied sulphur in the boiling condition was then taken in hand by the pumps, lifted clear of the ground, and discharged in a steady, viscid stream into a great bin fashioned from wood. It was left to cool and to solidify. Then the woodwork was demolished and the sulphur left standing a solid block, as hard as sandstone, ready for shipment.

The experiment proving a complete success, development was pushed ahead with all speed. Well after well was sunk into the deposit, care being taken to space the bore-holes a certain distance apart, this ranging from 50 to 100 feet. Batteries of boilers, each carrying from 15 to 20 units, and ranging from 150 to 300 horse-power, for superheating the water, were erected. One battery is required to operate each well, and the batteries are so disposed as to enable one man to supervise two groups of 30 to 40 boilers. Oil firing is employed, the requisite liquid fuel being drawn from the company's own oil wells sunk near by.

These boilers are kept going night and day, and millions of gallons of water, superheated to 350 degrees Fahrenheit, are sent in endless streams into the huge cone of sulphur, melting it down as if it were snow. In exchange for the water received the earth is giving up the molten sulphur at the rate of 400 to 500 cubic feet per day, and is keeping up the flow steadily for months on end. The sulphur, as received, is discharged into the enormous vats or bins which have been erected, and in this way huge monoliths of brightly-gleaming yellow mineral of unequalled purity are formed upon the surface. These are demolished by the aid of explosives and moved to the port fifty miles away, to be shipped to the world's markets.

At every point time- and labour-saving devices have been freely introduced. After the mass has been torn to pieces by explosives, the shattered mass is picked up by a crane capable of taking a mouthful of two tons at a time. In this way a 35-ton railway truck can be loaded in fifteen minutes. Arriving at the port the trains are unloaded and the cargo delivered into the holds of the waiting ship at the rate of 16 tons a minute, the transfer being made through special loaders delivering the material in a steady, continuous stream and operating automatically, only one man being required to carry out the unloading of a complete train of wagons. In fact, so effective is the transfer system in vogue that a vessel can arrive, receive 7,000 tons of sulphur, and depart within twenty-four hours.

To bring home the far-reaching effect which the Frasch system has exercised upon the American sulphur industry, a few figures may be related. Previous to the opening up of the Louisiana sulphur beds the total production of sulphur of the United States in 1901 was only about 5,000 tons. The coming of the Frasch invention sent the figure to 127,000 tons in 1904, while four years later it notched 369,444 tons! No wonder the Italian interest became alarmed in view of such an extraordinarily rapid rise of what was, and still is, an infant industry of America. At the present time the normal annual production is about 260,000 tons, which may be said to represent the steady figure.

Yet, notwithstanding the activity pursued by the American interests in exploiting the Louisiana deposits and the working of the Sicilian mines, the richest known sulphur deposit is to be found in a corner of the British Empire. About thirty miles off North Island, New Zealand, in the Bay of Plenty, is a group of rocks about three miles in cir-

cumference, forming what is known as White Island, so-called from the clouds of white vapour which always hang over the island, and which are composed of steam belched from the internal fires through the vents which the peaks offer, for White Island is a live volcanic spot. Scratch the drab surface of this island and one immediately comes across the characteristic yellow crystalline formation of sulphur. White Island is really one immense deposit of sulphur, and, what is more, encloses a lake some 50 acres in extent by about 12 feet deep, nestling about 15 feet above the sea level, surrounded by hills of solid sulphur and gypsum. The most remarkable feature of this lake is not its temperature, which is about 110 degrees Fahrenheit, but the liquid which it contains. This is a mixture of hydrochloric and sulphuric acids, for here Nature not only runs a sulphur factory, but an acid-making plant as well. On one side the lake is fringed with enormous blowholes, which are continuously belching clouds of steam which rise to a height of 10,000 feet or more, heavily impregnated with sulphurous fumes and showers of sulphur, while, as may be supposed, approach to this seething acid cauldron is extremely precarious and dangerous.

The sulphur is remarkably pure and, what is more to the point, production is continuous. It cannot be exhausted, at least not until the internal fires die down and refuse to blow off at this spot any more. Even then it will take scores of generations to exhaust the available sulphur, since the island juts about 6,000 feet above the sea.

So far White Island has failed to be exploited along methodical comprehensive lines for its mineral wealth. A certain amount of sulphur is mined, but the treasure-house is at present situate upon the wrong side of the world and

too far away from the most attractive markets. When Australia becomes as densely settled as is the United States to-day, doubtless the wealth of White Island will arouse more earnest attention, because it will be next door to the innumerable factories which will then be in full swing, and which will demand steady appreciable supplies of the "one-hoss shay" of industry.

CHAPTER V

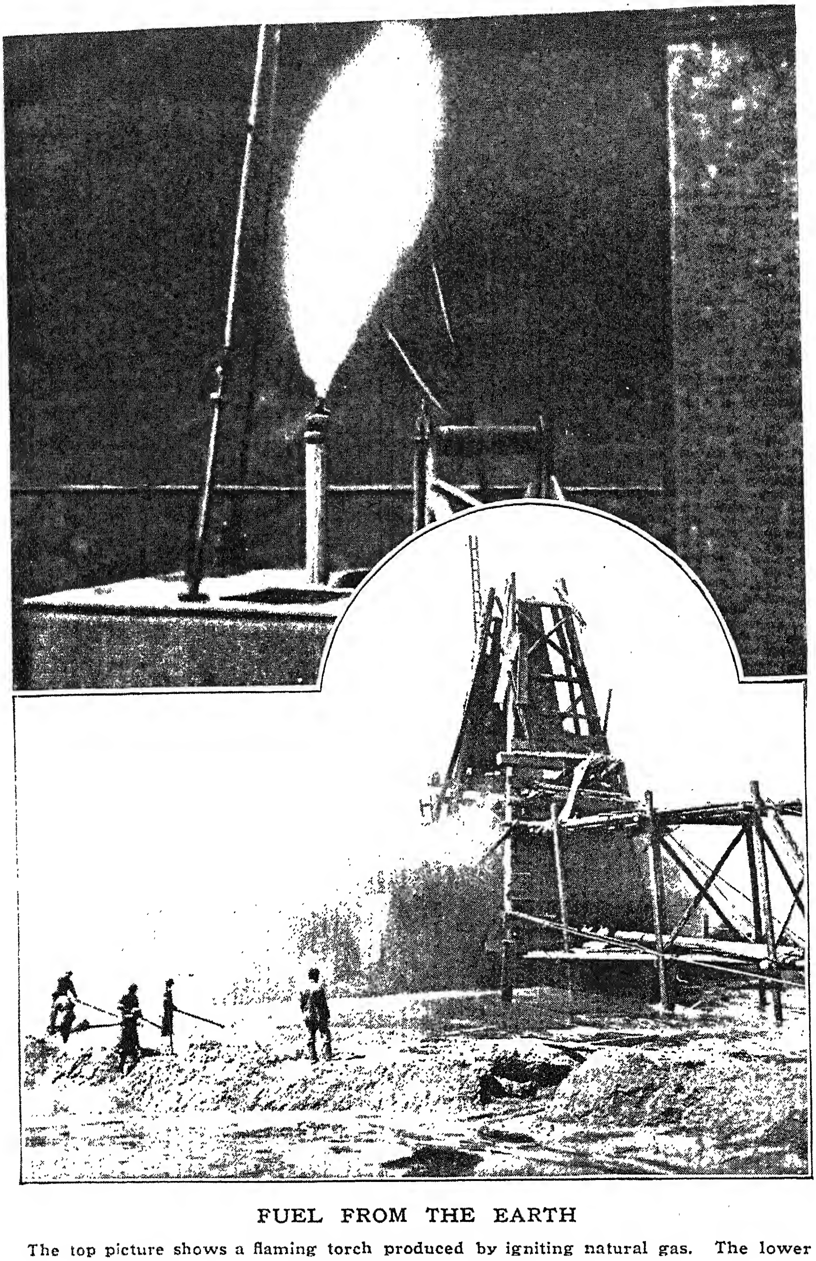
The Fuel of the Future

THE twentieth century is colloquially described as the Oil Age, and in certain quarters the theory is expressed that oil will ultimately displace coal as the world's premier fuel. Upon this point it is somewhat hazardous to express a definite opinion, but it is only too apparent that to-day coal does not occupy the overwhelming autocratic sway which it commanded during the nineteenth century. Coal secured a firm grip upon civilisation not only on account of its fuel properties, but because it is capable of yielding so many by-products constituting the raw materials for a host of trades, among which may be mentioned the production of aniline dyes, disinfectants, drugs and chemicals, to mention only a few of those which readily occur to the mind. But petroleum is capable of yielding just as many staples for other branches of endeavour, and, indeed, is competing with those derived from coal. This circumstance is not surprising, because, as previously stated, petroleum is really coal in another form.

One fact is so firmly established as to be beyond controversy. The lighting and heating properties of oil were appreciated long before the fuel possibilities of coal were ever discovered. For centuries the "Eternal Fires," the burning oil wells of natural origin in southern Russia, were patronised by fire worshippers, while we have conclusive testimony concerning the use of crude oil for lamps long

before any mention of coal is made. This is not so surprising as it may seem. In many places the oil forces its way to the surface, taking advantage of the cracks and interstices in the earth's crust to effect escape from its underground prison. It was surface traces of oil which led to its exploitation in England, and culminated in the most wonderful discovery recorded in connection with oil, and really ushered in the oil era. This was the invention of the British chemist, Young, of the process for refining paraffin from crude petroleum. For the most part the raw oil, as drawn from the earth, is of little use. It must be passed through various treatments to render it attractive to commerce, and it is these refining processes which split the crude products into a variety of commodities, from petrol to carbon for electric arc lamps, paraffin to vaseline, and lubricating oils of varying grades and consistency to asphalt for laying upon our highways.

It was Colonel Drake who, in 1859, drew the attention of the world to this treasure trove. He sank an oil-well in Pennsylvania, being persuaded to this enterprise by the discovery of Young concerning paraffin, the value of which for illuminating purposes becoming appreciated, had provoked a heavy demand for this commodity. The enterprising American struck oil in Pennsylvania at 69½ feet, and the news of his discovery precipitated a rush such as no discovery of a new goldfield ever has produced. Adventurers, prospectors, speculators, plungers, grim hard toilers and others flocked to the district, with the result that in a few weeks the earth for miles around was being feverishly punctured to tap the underground deposit of the precious liquid. The fever rose to unprecedented heights and raged with unparalleled virulence. Fortunes were made and lost in a day.



FUEL FROM THE EARTH

The top picture shows a flaming torch produced by igniting natural gas. The lower picture is of an oil field.

examination is not unduly heavy. The formation of the earth's crust governs the question, and this is why the geologist must be consulted. True, in this, as in every other case, he is likely to be baffled by faults, twists, turns and folds in the strata, but he certainly can assert with safety whether oil should or should not exist after mapping the formation of the earth's peel at a specific point.

In tapping the earth for oil the broad principles of the process followed for obtaining water by the artesian method is adopted. Over the site a lattice pyramidal tower is erected. At the top a roller is fitted, over which is passed a cable, the one end of which is connected to the boring tool. The other is passed round a drum, which is generally operated by a steam engine housed in a building extending from the foot of the tower. The tool is lifted to a certain height, to be suddenly released. The force of the impact arising from the fall shatters the soil beneath the tool, and in this manner a hole is driven. The soil pulverised in this way is removed by means of a pump, so that the tool is presented with a clean area of surface upon which to expend the full force of its successive blows.

It seems a very simple operation, and one for which the simplest of tools might be safely employed; but, as experience has proved, it is really a highly specialised craft. The broad principles of the system prevail, no matter where drilling may be carried out, but the tools employed are subject to wide variation, according to the location of the field and the character of the geological formation, while opinion differs widely concerning the efficiency of the percussive system, as the elevation and dropping of the chisel is called, and the rotary method of drilling.

The selection of tools is also governed in no mean degree

by the depth to which it may be necessary to carry the bore-hole, as well as the system whereby the oil is to be recovered. Then it must be remembered that the bore-hole must be driven as truly vertical as a plumb line, that accidents may be encountered, and for them due precautions must be observed. In fact, the driller has to be ready for any and every emergency.

The actual smashing up of the soil is accomplished by means of a bit or chisel, the cutting edge of which in its fall strikes the hard ground. It is not, however, a case of attaching a chisel to the end of a rope. A somewhat formidable array of incidental gear has to be connected to the end of the cable to form what the driller calls the "string of tools." The bit, which may be from 4½ to 6 feet in length, is screwed into the end of the auger stem. This may be 16 feet or 48 feet in length. Then come the drilling "jars," resembling big links of a massive chain, followed in turn by the sinker and the rope socket. The whole string of tools may weigh up to two or more tons, of which the bit itself perhaps weighs one ton. Some of the chisels are of formidable proportions. Thus in Russia, where it is necessary sometimes to drive a hole 25 inches in diameter, the bit may run up to 10 feet in length and turn the scale at 1½ tons. In such cases the total weight of the string of tools may be readily imagined.

The string of tools is not withdrawn to the top of the derrick after each stroke, but only to a predetermined height, the fall being calculated with extreme care. To assure the tool being released with the desired suddenness special facilities are incorporated. The tool is permitted to strike the bottom of the bore with the maximum natural force and to bounce upwards as far as it will, it having been found to be preferable not to attempt to check the extent of the rebound.

At this moment the engine picks up the rope, lifting the chisel to the predetermined height, when the cycle of operations is repeated. In a similar manner arrangements are introduced to pay out the rope as the hole increases in depth so that the fall is always kept uniform. The debris collecting at the bottom of the hole is removed by means of water and a sand pump.

Should the bore-hole get out of the true the deviation is corrected by re-drilling from the point where the error commences. As the hole is bored, casing is introduced in the form of lengths of pipe of the desired diameter. The casing sinks down gradually, and when the projecting section has reached a certain point, a new length is hauled up and screwed in to that already sinking, ponderous and weighty tongs being used to carry out this task. In screwing the lengths into position care must be observed to see that they are screwed home true, because any deviation in the casing itself is likely to mar subsequent operations concerned with the extraction of the oil, especially if pumping should have to be adopted.

Occasionally a string of tools, or part thereof, will break away and tumble to the bottom of the hole. A pretty mess is presented, and the situation is not attractive in the case of a narrow bore, not more than 6 inches in diameter, with the break-aways resting at a depth of 1,500 feet. But the driller, while exasperated, is not perturbed. Special and highly ingenious fishing tools have been designed to cope with such a *contretemps* as this. They are lowered into the hole and there ensures a burst of blind sport. The fishing tools are of varying design. One will grip a piece of tool or any tool which has accidentally fallen down the bore. Another is constructed to catch hold of the broken cable. A third can cut the cable if desired. A fourth will loosen the

tools which may have become jammed in the hole, and so on. Very rarely is it that a hole has to be abandoned nowadays because it has become chocked by break-away tools and tackle which refuse to be extricated. Months, perhaps, may be involved in overcoming such an accident, but the driller will eventually win, even if he has to have special tools designed for the particular job.

Sometimes the hole collapses, burying the tools beneath it. The driller does not give up his task, but immediately sets to work to repair the damage and to recover his gear. By means of what he terms a "fluted swedge" he starts to drill through the material blocking the passage, and when he has fulfilled this operation he has left the bore-hole as clean and as true as it was originally.

The rotary system differs widely from the percussive method. It involves a more elaborate plant, and can only be employed so long as there is plenty of water available, this being used freely because it acts partly as a lubricant. The driller describes this as the "mud-flush" system because the water, a circulation of which is maintained, combines with the removed debris, converting it into a slime or mud, and flushes it to the surface. It has a distinct advantage when drilling through sand. The water introduced down the pipe, passes underneath the bottom or cutting edge, and ascends outside. The flush being a mud this will cling to the face of the sand, and in a short time will form a wall which is capable of holding back the unstable soil until such time as the casing can be introduced, when, of course, all danger of obstruction from collapse is passed.

In the rotary cutter a column of drill pipe is used at the lower end having a circular cutting edge. This, as the term implies, is rotated through worm and gearing. As the water

has a circuit down the drill pipe, under the cutting edge, and upwards between the outer surface of the drill pipe and the wall of the bore-hole, the drill pipe is really floated, not coming into contact with the bore-hole at all, the water acting as a cushion or lubricant. Not only does the water circulation carry away the debris as rapidly as it is created, but at the same time it serves to keep the cutting edge cool. The process, while not so extensively practised as the percussion system, is eminently adapted to driving a bore through sandy and water-laden soils which, naturally, are distinctly treacherous.

As the drilling tools sink lower and lower, and the region at which oil may be expected is approached, the driller keeps his eye open for the characteristic indications. As a rule signs of gas are first observed. The petroleum layer, far below and sealed from the surface by a dense and impermeable crust, acts both as reservoir and gasometer. The lighter constituents of the oil, forming a gas, collect upon the surface of the petroleum. As the drill descends the shocks and jars shatter pockets into which the gas, in its vain ascent, has collected. It now comes to the surface, and its presence warns the driller to "get ready." If the gas exudes in appreciable proportions it is either led off to a safe distance to dissipate into the atmosphere, or is controlled and led to the boiler-house to assist in raising steam. It may even be sealed to prevent its escape, but this is only done when it is tapped in large quantities, because natural gas, as it is called, possesses a distinctive value when abundant.

When the tool breaks into the oil-bearing strata or "paying sands," as they are called, the petroleum may assert itself in no uncertain manner. Exerting enormous pressure below the moment the weight of the earth falls below the force of

the thrust being exerted by the oil, there is a violent smash up of the remaining layer of crust, accompanied by a roar. The oil flies up the well-hole with terrible fury to burst into the air. It will spout, perhaps, to a hundred feet or more. This is the type of strike which the expert driller dislikes. It is a gusher, and he knows full well that there is trouble ahead unless he is extremely careful. All fires have to be damped down, otherwise there is the likelihood of a sudden flare up. While a blazing oil-well may present a terrifying, grandiose spectacle, it is about the worst foe which can confront the driller. To extinguish a burning oil-well is no easy matter, even if it be only a flicker. Should it prove a roarer, the intense heat will drive everyone to a respectable distance. Approach to the torch will not only be well-nigh impossible, but extremely hazardous. Many expedients have been tested for extinguishing a flaming oil-well, but the most effective yet discovered is live steam. To attempt to effect the desired end with water is merely to aggravate the calamity. Sand is another useful material to have in abundance within convenient reach to smother a fire in its incipient stages.

Fire is the most relentless enemy of the oilfield, and should a big gusher catch fire the possibility of salving the well is virtually hopeless. When the giant gusher "Dos Bocas," on the newly opened Tampico oilfields caught fire, it created consternation in all directions. It is estimated that 4,000,000 barrels—over 160,000,000 gallons—of petroleum were pouring from this well during the twenty-four hours. When it burst into flame it produced a gigantic torch leaping to a height of 1,000 to 1,500 feet, the glare of which at night was visible 200 miles out to sea. Superhuman efforts were made to rescue this well from destruction, but to no avail. It raged furiously, finally burning itself out, the petroleum

ultimately giving way to salt water. It is estimated that petroleum to the value of over £5,000,000 went up in smoke from this well.

If a well bursts into activity suddenly upon a big scale, extemporised methods have to be practised to care for the product. Embankments are thrown up to form depressions or lakes of petroleum. Meanwhile, every effort is made to control the flow by means of the gate and valve which are swung into position over the mouth of the bore-hole and screwed home. Those engaged in the task are certain to become saturated from head to foot in oil—they are known as "greasy men"—and they will emerge from the site dripping oil as a man sheds water when walking out of the sea.

For every well which breaks its bounds in this unceremonious manner, there are scores which come to life very sluggishly, as if resenting disturbance and release. The oil surges slowly up the well to fall lazily over the top. As a rule a shallow pond or sump has been prepared at the foot of the tower to receive this preliminary yield, or perhaps, as in the case of a proved area, tanks have been set up in readiness, although, as a rule, tank accommodation is not taken in hand until the oil has been tapped, on the principle of first strike your oil and then catch it. But signs of oil do not necessarily indicate that the paying sands have been actually attained. It may be an upper and isolated pocket which has been struck, and so drilling is continued, the free oil being caught and controlled meanwhile. If the oil stratum has been truly entered and the oil is issuing lazily, the next step is to give it a boost to hasten the flow. This is done by means of explosives—"shooting the well," as it is called. A charge of nitro-glycerine is poured into the hole and fired at the bottom. The resultant explosion shatters all obstruction to

the lower opening of the pipe, and the oil, if present, comes forth more freely At the same time the firing of this charge forms the cavity at the bottom of the bore which is desired to receive the oil previous to its journey up the well-pipe, and also allows the sand with which it may be associated to settle out.

When the well is a gusher all difficulty concerning the extraction of the oil is solved; Nature supplies the requisite energy. But when the yield is sluggish it is necessary to have recourse to pumping. In Russia the method most extensively practised is known as bailing. This is a long cylinder, possibly 36 feet in length, which is lowered into the well after the manner of a bucket, to become filled with oil, when it is hauled to the surface to be emptied. Such a method is slow and expensive, even in countries where labour may be inordinately cheap, and this is not to be compared with mechanical methods.

The cost of sinking an oil-well varies widely, being governed by the depth to which it is necessary to drive the tools, as well as the character of the country in which the work is conducted. In Canada, where shallow low-yield wells are extensively sunk, perhaps to 400 feet, the cost of the undertaking is about £20. In the Baku oilfields the cost averages about £5,000, while in Galicia, where it is necessary to descend 3,000 to 4,000 feet, the cost of tapping the oil runs up to £6,000 and £8,000.

An oil-well is probably the most speculative form of investment that one can possess. It is liquid in more senses than one, because no one can tell when it will give out. It may yield consistently for weeks, or even months on end, and then suddenly decline to contribute a further ounce of the treasure. For this reason an oilfield often has but an

ephemeral existence. The district around the spot where Drake first struck oil, which was the scene of such frenzied activity in 1859, and where derricks were as densely packed as bees in a hive, is now smiling farming land. The wells gave out in due course, the towers and other buildings were demolished, and agriculture once more gained the upper hand. Many of the localities which achieved a world-wide name in those roaring days—places like Funkville and Wild-cat Hollow—are to-day naught but memories.

So far as Great Britain is concerned, but little petroleum has ever been struck in the liquid form. There was a well in Derbyshire which enabled Young to carry out his momentous investigations, while we have great hopes of tapping this treasure in that region through the enterprise of Lord Cowdray and his vast resources in brain and equipment. Discovery of oil in large paying quantities would be certain to revolutionise the whole of our national life. At the present moment we are dependent for native oil upon the shales of Scotland. This shale is a black, slaty material somewhat resembling a low grade of coal, but is relatively rich in oil. The rock is mined in the usual manner, and is then subjected to a distillation treatment, broadly analogous to that followed with coal in the manufacture of coal-gas. Efforts have also been made to turn similar oil-charged shales to commercial account in other parts of the world, notably Australia; but the results achieved have not been eminently satisfactory. Scotland still remains the one country in which this industry can be pursued with profit, although naturally the process is more expensive than where it is possible to bring the petroleum to the surface in a liquid form merely by driving a bore-hole.

Another valuable substance closely allied to petroleum, being, in fact, a product thereof, though carried out by

Nature, is natural gas. This is even found in the British Isles to a very limited degree, notably at Heathfield in Sussex, where the railway company, in the course of boring for water, struck a vein of this gas. It was harnessed and utilised for lighting the station premises, and continues to do so. In other parts of the world, however, more especially the United States and Canada, it is found in immense quantities. In some instances it is even piped two hundred or more miles to feed furnaces as well as to light homes and factories. In the United States the annual consumption of gas runs into millions of cubic feet during the course of the year. In Canada, the centre of the oil industry is Medicine Hat, the Canadian Pacific Railway charges the cylinders of the railway coaches wherewith to provide lighting, and to cook the meals served to passengers in the dining-cars.

Drawing upon Mother Earth for gas supply represents the simplest and cheapest means of gaining this contribution to the amenities of civilisation. Bore-holes are driven in the usual manner into the natural gasometer lying far below. The gas is not led into tanks and thence distributed to the public through supply mains, but is led direct from the earth to the gas-burner in the home or furnace in the factory. All that is required is to provide a controlling and efficient gas pressure-reducing valve at the mouth of the bore-hole. At Medicine Hat the gas rushes from the earth at a pressure of 550 pounds per square inch, which is useless for domestic purposes. By means of the regulator this pressure is reduced to 50 pounds per square inch. In such a district as Medicine Hat, where natural gas is available, the worries in connection with bills for this commodity are trifling. The domestic rate averages about 7½d. per 1,000 cubic feet, while manufacturers are able to satisfy their needs in this field for 2½d. to ½d.

per 1,000 cubic feet. Yet it was not so many years ago since the oil-well drillers regarded the gas issuing from their wells with dismay, dreading the outbreak of the fire-fiend. They led it away through pipes to a safe distance, and then ignited the jets, allowing them to burn until the gas had been exhausted.

During recent years natural gas has been carefully collected for another purpose. The development of the aeroplane, airship, motor-boat, motor-car, and motor-cycle has invested petrol, the volatile product of petroleum, with extreme value, and the demand is in excess of the supply. It was found that petrol was associated with natural gas in a finely divided form. Accordingly, it was decided to exploit the natural gas for its petrol content. The gas is drawn from the well and is passed through a compressing plant, which has the effect of squeezing or wringing out the petrol. This spirit, known as "casing head oil," is strikingly pure and extremely volatile, so that the latest manifestation of the search for oil may be said to have resulted in the elaboration of a practical process for the recovery of a high-grade petrol direct from Nature's reservoirs.

Oil is not only found in a freely flowing liquid form. In certain parts of Galicia it is recovered as a jelly, while in other parts it is mined, the product being commercially known as ozokerite. In some cases the substance has a transparent, yellowish hue, and is soft though solid; while in other instances it is of a resinous character, perfectly hard and dark. It is mined with the soil, being subsequently separated therefrom by melting. Oil is occasionally found in the form of tar sands, one large occurrence of which has been discovered in north-western Canada. By submission to a heat treatment, the sand can be expelled from the oil. Another unusual form

has been exploited upon a limited scale in California. Here the oil is found in a plastic state, capable of being cut with large scoops. The proportion of oil is not high, and it is rather viscid when recovered, which probably accounts for the deposit in question having been neglected. It has been suggested that this material might prove of commercial value as a road-paving material, but the recommendation, so far, has not met with favour.

Probably the asphalt lake of Trinidad is the most extraordinary deposit of a commercial article associated with the oil group. This is not only the most remarkable lake in the world, but one of the unsolved riddles of science. The lake is about 115 acres in area, and in the centre its depth is quite problematical, because so far it has defied sounding. But the most wonderful feature of this lake is that it cannot be emptied. Thousands of tons are removed annually, only to be replaced by fresh supplies forced up from below. Sir Walter Raleigh discovered this "freak" of Nature, and promptly christened it Pitch Lake, but its exploitation was first taken in hand only about sixty years ago.

The pitch, while soft, will readily support the average person. Early in the morning it may safely be crossed by horse and cart, while by distributing a thick layer of palm branches, a road capable of bearing a light tramway has been laid. The asphalt is always soft, so that excavation is relatively easy. Work can only be pursued during the morning and afternoon; during the middle of the day it is too hot to be suffered. Pitch Lake has been colloquially described as the hottest place on earth. No matter how much may be removed during the day, no traces of the displacement are visible the following morning. Nature has replenished the stock.

The lake is generally considered to be the crater of an extinct volcano having connection with one of Nature's subterranean factories. One might be disposed to criticise the association of the bitumen with petroleum, but one group of crude oil is known as the "asphaltic," from the fact that the base is asphalt. In other words, when all other products have been extracted an asphalt remains with which the contents of Pitch Lake have many features in common.

The asphalt is utilised as a road-paving material, many town and city thoroughfares being paved with it. Paris pioneered this development about 1870, but the experiment did not prove a success. London then essayed to establish its value in this field and succeeded, since when it has come into extensive use, especially in the United States, where it has also superseded coal tar for many purposes. An American company secured the concession to work the deposit, and in the course of twenty-one years removed a round 2,200,000 tons from the lake. There are, nevertheless, no evidences of such a heavy withdrawal; the pitch still marks the level recorded when the company first started operations.

In Venezuela there is another asphalt lake having a superficies about nine times that of the sheet in Trinidad, but it is relatively shallow, differs in character, and does not appear to have any connection with the interior of the earth. Cuba can point to similar deposits, while the Red Sea belches a certain amount of asphalt, attempts to exploit which have been made from time to time. Other occurrences are to be found in Asia Minor, Persia and Mesopotamia, while in Texas and Utah veins of the material, in a dense solid form which requires to be mined like stone, are regularly worked.

While oil in some form or another has been known to the peoples of the world for thousands of years, it is only

GARNERING THE HARVEST OF PITCH

Men gathering asphalt from the great pitch lake of Trinidad.

within the past half century that its commercial possibilities have aroused serious attention. Although we have not proceeded far with the development of this material and its numerous by-products, commerce is already subsisting upon a round three hundred raw materials derived from petroleum. It is driving coal hard for recognition as the premier fuel, especially as it is found in many countries which, as far as geological knowledge has carried us, are as bare of coal as is the snake of fur. Bearing in mind the assiduity with which its properties are being advocated and appreciated, perhaps the time is not so far distant as it may at present appear when the world will be dependent not upon coal, but upon oil as the life-stream of commerce, industry and domestic existence.

CHAPTER VI

Salt—The Mineral without which the Animal Kingdom Cannot Exist

WHAT is the mineral with which the animal kingdom could least dispense? This is a riddle which will bring a crop of varying replies. Some will say coal, others iron, still more gold, and so on, ignoring the circumstances that for each of these apparently indispensable treasures of the earth a substitute may be employed, or that the value with which a product is endowed is essentially fictitious. It is safe to assert that few people would hit upon the one organic substance derived from the earth without which life would be impossible. At the same time it is probably the most abundant inorganic substance which we have, being found in every part of the world.

The mineral in question is salt—the common white substance to be found upon every dining-table and in the kitchen. However, its utilitarian value is by no means confined to domestic circles, inasmuch as it constitutes the backbone of the vast soda industry. Nature maintains a gigantic salt producing factory spreading from Pole to Pole, because the ocean is manufacturing this commodity continuously, using the sodium brought down by the rivers and combining it with chlorine to form the familiar substance. Salt production is conducted by Nature in the ocean, and not upon the land, as might be supposed, at least only to a very insignificant

degree. We dig or pump the salt for the most part, however, from the solid earth, which is liberally and thickly veined therewith. Accordingly, in view of this circumstance, one might naturally ask how it is the salt got there, if Nature does not run a salt-making factory upon dry land?

The riddle is not so baffling as it appears at first sight. From time to time Nature flies into a tantrum, and there ensues a pretty to-do. The surface of the earth is strangely contorted, stretches of land disappearing from sight beneath the waves here, while the sea bed becomes forced high into the air there. In the past Mother Earth must have been a very unstable sphere, and centuries must have passed before she settled down to a quiet and relatively peaceful existence. She must have been extremely undecided concerning the ultimate disposition of the water and land, as we have learned from driving big augers into the crust to test its composition.

In these periodic upheavals shallow lakes of salt water were formed. In course of time they dried up, the salt being left in the form of a sediment or crust. As the lakes were not elevated to a pronounced degree in the first instance, the sea gained periodical access to the depressions, flooding the area once more, and in turn becoming dried up, leaving a thicker skin of salt. So the process went on intermittently, and in this way the thickness of the salt deposit was increased. Finally there was a terrific cataclysm which buried the salt far beneath a layer of rock and earth.

In some instances these deposits have been buried to an extreme depth, one which is probably far below the endurance of man. The salt is, however, being brought to the surface. Underground springs have carved their paths through the salt veins, dissolving the mineral once more,

and bringing it to the surface, where re-crystallisation takes place. These become covered in time with layers of drifting sand and other debris. In due time the layer is discovered, and if the conditions permit the deposit is worked.

Salt being indispensable to the maintenance of the wonderful engine constituting the animal body, its recovery from the earth is extensively practised throughout the world; and it is secured in a variety of ways. In some places natural action is conducted upon a limited artificial scale. In other places the mineral is mined, while in some instances it is brought to the surface in the form of brine by the aid of pumps.

The reproduction of the natural concentration process is conducted upon a more or less comprehensive scale in America, Australia, China, and even southern Europe. Economic considerations so compel. Salt is a curious commodity in which to trade. It is so freely distributed and finds such a ready market as to be in steady and constant demand. Nevertheless, it must be vended at a low figure. Consequently the cost of wresting it from the earth must be carried out along the most economical lines, while secondary expenses, such as cost of transport, must be reduced to the absolute minimum. Scattered throughout the world are vast proved beds of salt, carrying hundreds of thousands of tons, but they are not being worked, merely because they are too remote from the consuming markets, and the cost of freighting the article would be too prohibitive. Man demands cheap salt, and he spares no individual effort to get it. Thus the rancher, who is unavoidably situate some distance from a town, will seek for it upon his own estate especially to satisfy the needs of his cattle. In dry countries he does not as a rule experience great difficulty in this con-

nection. The hot summer sun lowers the level of the watering places, and in so doing generally leaves a white rim of salt upon the bank, which the animals greedily lick, and which the rancher gathers for all purposes, except his own consumption, which he can meet with purchases when he ventures into the nearest town.

The influence of the cost of conveying salt from a proved area to a distant market is brought home very convincingly upon the western seaboard of the United States of America. San Francisco is a big city, while there are many teeming towns and villages scattered around it; but the accepted salt-producing centres of the country are many miles to the east, and the cost of carrying the salt would lift the price of the commodity to an intolerable level. Accordingly the production of salt upon the broad lines practised by Nature is pursued in the vicinity, thus ensuring an adequate local supply.

To carry out Nature's concentration process certain conditions are essential. In the first place the sea, with its inexhaustible supply, must be to hand. Secondly, the lay of the land must be such as to admit periodical shallow flooding over a large area, which means that the salt producing pan must really be a level plain contiguous to the sea and lying but a few inches above it. Thirdly, and this is the most important factor, the sunshine must be assured over long periods, with relatively intense solar heat to assure rapid evaporation.

Such imperative fundamental conditions exist at Alvarado, twenty miles distant from San Francisco. Here the sun shines for weeks on end, the climate is intensely dry, the humidity is low, while the soil is a stiff clay, forming an excellent bottom to the huge dishes or basins. The site is

additionally admirable because, but for an embankment which has been erected, the land over 1,000 acres would be flooded with every high tide, the highest point of the pans being only four feet above mean high tide level, which readily allows the reservoirs to be filled by gravity. The company which has embarked upon this novel industry is also assured of adequate supplies of fresh and pure salt water, inasmuch as the indent is totally free from contamination by effluents from the land.

This novel hive of activity is strikingly reminiscent of a typical stretch of Holland, with its geometrically set out fields bounded by low-lying banks, communicating ditches, and array of windmills which are used for pumping the sea water from one field into another. The *vraisemblance* is completed by the deep canal which extends through the property to the refinery which has been established, which enables vessels of heavy draught to proceed to the refinery basin to receive their cargoes.

Altogether the company in question has roped in 1,000 acres of the low-lying plain, and the area is enclosed and subdivided into complete sections by embankments aggregating twelve miles in length, while there are some eight miles of interconnecting ditches. The windmills which have been erected have a total lifting capacity of 200,000 gallons of salt water, or brine, as it is called, per minute. Each pan, before being brought into service, was rolled and re-rolled to present a flat, hard, packed, impervious, level clay bottom, three years being occupied in the fulfilment of this imperative preliminary.

The practice followed may be described as continuous and intensive. At high tide sluice-gates are opened and the sea is allowed free access to the first large reservoir.

Photo.: Putnam Walentine, Los Angeles

SALT FROM AN INLAND SEA

In the Ca'ifornian desert there is the bed of an inland sea which, evaporating, left huge deposits of salt.

When the field has been flooded to a depth of 36 inches the gates are closed. The virgin sea water varies in salt strength from 5 to 7 degrees, and it is allowed to remain in this reservoir until evaporation has increased the salinity to about 30 degrees. The brine is now lifted by windmills from the first reservoir, to be discharged into the second adjacent field, where it is left exposed to the sun until salinity has increased to about 60 degrees, the first field meanwhile having received a fresh supply from the sea. The heavy brine is again lifted by windmill over the intervening embankment into the third field, the emptied second field being recharged from the first pan, which in turn receives a third charge from the sea. So the water passes forward from field to field, increasing in salt strength in its passage, fresh supplies following on immediately.

The reservoirs, four to eight, are known as settling ponds, because here the brine voluntarily sheds one of its impurities —the lime—while by the time the requisite degree of evaporation has been completed, a saturated salt solution, the percentage of salinity being about 90 degrees, is obtained. From these settling reservoirs the brine is discharged into a numebr of other pans, and here the concentration process undergoes acceleration because the proportion of water is really low, the fierce Californian sun completing its work speedily. The salt precipitates, forming a thick layer or sediment, within about twenty-one days, the remaining solution, or pickle, being drawn off and allowed to escape by gravity, because these final reservoirs are located upon the highest reaches of the land.

The crust of salt is permitted to lie exposed to the fierce sun for a few days, when it is harvested. It is shovelled into small pyramidal heaps, to be transported by wheel-

barrows to the embankment, where it is transferred to the vehicles to be carried to the refinery, or, if crude salt be required for industrial purposes, such as tanning, it is loaded right away into the ships for dispatch.

As may be supposed the recovery of this treasure can only be conducted during the summer season, when the solar heat is fiercest and may be relied upon to prevail for a long period. Two harvests are made during the year, in August and October respectively, and the yield is distinctly profitable. When the salt has been removed the pan is thoroughly cleaned, and the bottom subjected to another rolling to consolidate it and to prevent all escape of brine through percolation. Although we say the sea is salt this salinity is somewhat misleading. The salt is not pure. It is associated with such deleterious substances as lime, magnesia and potash. The first-named settles out for the most part as already mentioned in the reservoirs, but the remaining portion, together with the other deleterious substances, are eliminated during the ensuing manufacturing operations.

This industry is pursued upon less pretentious lines in Australia, large quantities being obtained from "salterns," as they are called, and also from shallow lakes, which naturally dry up during the hot summer days, leaving a crust of salt lying on the bottom. There is one stretch of water, Lake Hart, some sixty miles in area, constituting an excellent natural salt-yielding pan, but, owing to the distance of the deposit from the market, it is not exploited at present. The recovery of the salt is conducted along the simplest lines in Australia, merely being scraped from the dried-up lake beds during the summer. In harvesting the salt care has to be observed not to remove the whole of the deposit, but to leave

a thin crust behind. These pans are of natural formation, the lake-bed being merely mud, and no effort is made to line and level the surface with a stiff impermeable clay to secure watertightness. If too thin a crust be left behind the resultant crop after the winter rains will be smaller. In this instance it will be seen that the salt is recovered from the soil and carried in solution to the lake to undergo ultimate precipitation under solar evaporation.

In Southern Russia salt-farming is carried out upon lines broadly similar to those followed in California. Here the salt, after evaporation is completed, has a distinctly pinkish tinge. The mineral is alive, swarming with animalculæ, to the presence of which the strange colouring is due, but exposure to the sun and air subdues this life completely, the pinkish hue giving place to the glistening white characteristic of salt.

Open-air evaporation, or salt-farming, is hopelessly impracticable in Britain for reasons which will be obvious where Old Sol cannot be depended upon, while the climate is insufficiently dry. Yet there is all the salt required and it is systematically exploited, Britain ranking as the second largest producing nation in regard to this commodity in the world, premier position being occupied, as may be imagined, by the United States of America. The salt beds of Britain underlie what are colloquially known as the "Wiches," from the circumstance that Droitwich is the centre of activity identified with the recovery of this form of treasure trove.

The salt is disposed in thick veins and at levels varying between 124 and 300 feet. In some places it approaches rather nearer the surface, while elsewhere it dips down, but the foregoing may be accepted as representing the general

disposition of the beds. The uppermost layer, encountered about 124 feet down, is approximately 75 feet in thickness, and is covered with a thick crust of rock and topsoil, although the rock cannot be said to be possessed of any pronounced density or strength. The second vein of salt is about 90 feet thick and is separated from the one above by an intervening layer of rock.

In Great Britain the salt is recovered both by mining and pumping, although the second system was the direct outcome of the first method. The mines are relatively shallow, but when mining for the salt was first essayed the pioneers were content with the uppermost stratum, possibly being too excited to drive their drills deeper to tap the second and lower vein. Accordingly, the upper layer was first worked, and to such an extent that underlying Northwich and its environs is a massive chamber, 17 acres in area by 17 feet in height, which has been produced by excavating the salt. In mining the salt a system broadly analogous to the pit-and-stall method practised in certain coal mines was employed, massive pillars of solid salt being left at intervals to sustain the unstable roof, the weight of which is increased by that of the streets of buildings above.

At a later date the lower and thicker vein of salt was discovered, and so the shafts were carried down to about the 300 feet level. But even at this depth the shaft is relatively short, the salt being excavated from shallow workings. The salt itself is packed densely and solidly, forming a rock, and can only be obtained by recourse to blasting. The output from the mine is approximately 1,250,000 tons a year, and as one ton of salt represents about one cubic yard, it will be seen that at least 1,250,000 cubic yards of material are being withdrawn from the crust of the earth during the twelve months,

and is consequently leaving a steadily increasing gaping hole.

In a previous chapter I have referred to our activity in rescuing wealth from the earth being comparable with the man sawing a branch from a tree while seated astride the branch itself, and explained that we through our mining activity were really cutting the supports from beneath our feet. In Northwich the truth of this statement is brought home very vividly. The ground upon which the town is built is steadily caving in, the skin of soil and rock 124 feet thick upon which the buildings are resting proving to be too weak to support the superimposed weight. Subsidences are occasionally encountered in coal-mining areas, but in no other part of the world is such a striking illustration of what this signifies as a result of mining activity as in Northwich. Widespread havoc is caused from time to time through the unexpected collapse of buildings, and in certain instances the subsidences have been decidedly severe.

The collapse of the roof of the cave which has been formed, and upon which the town stands, while due to the removal of the salt beneath, has not been directly precipitated by such action. The pillars of salt left standing would have been adequate to sustain the weight but for the sudden appearance of the arch-enemy to every mining enterprise—water. This restless liquid, possibly imprisoned somewhere in the vicinity, in its search for an outlet, discovered the caves wrought by the miners by the removal of the salt. It not only invaded some of these areas, but pushed its way into the adjacent upper vein of salt. Unfortunately this mineral is not proof against the advances of water. It is readily dissolved and absorbed, thereby forming brine, which represents water carrying twenty-six degrees of salt. Thus the erstwhile

upper vein of the whole crystal rock has become converted into a huge underground reservoir of brine. Any pillars which were left supporting the roof were likewise demolished by the insatiable water, the result being that the roofs of the underground caverns were held up by water.

All would have been well had not some enterprising pioneer conceived the idea of recovering this brine and driving off the water to release the salt. He made the experiment and proved its commercial practicability. Forthwith brine-pumping developed into an important industry, and in this way thousands of tons of salt-soaked water have been, and still are, being lifted from the subterranean saline lake to be passed through fire-heated evaporators. It is easier, simpler, and less expensive to pump salt to the surface than to mine it in the usual manner, and so the country of which Northwich is the centre is now dotted with brine-pumping installations. It was the removal of the brine which precipitated Northwich's dilemma, because the water not only carried away the salt, but, at the same time, weakened the roof of the cave in which it was held by penetrating the formation. Water is capable of wreaking more damage in any mining enterprise than all other adverse forces put together, and Northwich offers a pathetic illustration of this fact with its tumbling buildings, fissured fields and roadways. Indeed, the losses incurred from these subsidences became so acute as to lead to the inauguration of a Compensation Board by Act of Parliament, which has the power to make a levy up to 1½d. per ton upon all brine pumped to compensate those whose property suffers from this treasure-seeking activity.

Salt-mining is pursued throughout the world from what may be described as sordid commercial motives, but there is one area where the winning of this indispensable commodity

is carried out upon commercial, æsthetic and even religious lines. It sounds a weird combination, but it is nevertheless true. At Wieliczka, in Poland, is an underground city of salt. It is a city in the fullest sense of the word, with its magnificent cathedral, crucifix, altar, pulpit and statues of saints, magnificent ballroom, bewildering lay-out of broad streets, narrow alleys and culs-de-sac, restaurant, railway station and other features incidental to every surface colony, but all sawed out of the solid salt.

At this spot Nature has been exceptionally lavish in her bestowal of salt deposits. Not only does the vein extend for miles, but it is extraordinarily thick—how thick may be judged from the fact that the roof of the ballroom is 190 feet above the floor. It is a strange city in every sense of the word, and its foundation is lost in the misty depths of time, although certain it is that the salt has been continuously quarried in these mines for over 1,000 years, and is in full swing to-day, because the vein appears to be interminable. As is well known the Galician is a religious zealot, and has an innate artistic taste. So when the quarrying of the salt was commenced the workers thought they might just as well fashion the huge caves along æsthetic lines as to leave them gaunt and ugly square-walled spaces. In their devout fervour they passed their spare time committing the traditional features of their saints into salt, possibly as a thankoffering for their daily bread, although, seeing that their wages have always averaged from 2½d. to 1s. per day, it does not appear as if they have had much for which to be thankful, especially for labouring in the depths of the earth.

However, Wieliczka, the underground city of salt, has become one of the sights of the world. It is, or rather was, the property of the State of Austria-Hungary, and it was

most jealously guarded, permission to view the strange wonders being grudgingly given. The workmen, of whom there are about 2,000, toil unceasingly day and night, work being divided into three shifts, because the country must have salt. The only breaks they enjoy to their endless round of labour, for a mere pittance, are the occasions when they are free to give expression to their feelings in fête and festival in the city underground. The life is rigorous. The workmen are zealously searched not only when entering and leaving the mine, but at intervals during their work, lest they may have a few ounces of salt concealed upon their persons. Salt has been regarded as currency, has been the subject for taxes wherewith to discharge a national obligation, but it can be readily acquired for the most part in any part of the world for a few pence a hundredweight, so why such zeal in searching the workers for a few ounces of this mineral should be the practice at this mine is somewhat inscrutable.

The salt is obtained in plenty. At times huge masses weighing several hundred tons come crashing into the street. In driving new thoroughfares the walls are chiselled and blasted with extreme care to maintain symmetry, while at other points, such as the spots to which several streets converge, a spacious circus and amenity of more or less utilitarian value is created. Thus, at the central point, is a handsome station with restaurant, having slender pillars and delicate balustrading wrought in salt, albeit the station merely represents the terminal for the narrow-gauge light railway along which the vehicles, laden with quarried salt, are hauled by ponies. The city is freely interspersed with large lakes and mysterious subterranean streams upon which ply ferrying and other craft, while a fairylike aspect is imparted to the spectacu-

larly carved ballroom and other apartments with chandeliers wrought in wire, but upon which rock-crystals have formed, reflecting the colours of the rainbow.

Owing to the system of quarrying followed in this strange city free recourse has to be made to timber shoring to support the vaulted roofs. Consequently the hazards prevailing in this mine are far greater than obtain in other mines devoted exclusively to utilitarian purposes. At times the timbers collapse under the intense strain imposed, and many terrible accidents have been recorded from this cause. Then the free use of timber accentuates the peril of fire. Conflagrations have freely broken out in the workings, and, having ample food upon which to flourish, have blazed away merrily or sullenly, as the case may be, until the wooden props have been consumed. Another terrible risk is that arising from explosion. At times pockets of deadly inflammable gas are penetrated, and, coming into contact with naked lights which abound, spread disaster far and wide.

Another equally imposing but less spectacular wonder of the world is to be found in East Africa. This is the immense sheet, covering thirty square miles, of soda—a product of Nature's factory into which salt enters—known as Lake Magadi, which is estimated to contain 200,000,000 tons of this useful commodity. But Lake Magadi recalls the pitch lake of Trinidad to which I have referred later. It would seem to be inexhaustible, because underground springs deposit fresh supplies, bringing them from the unapproachable works placed far below, to make good the losses incurred as a result of mining the product. This soda is of remarkable purity, being free from sulphur and capable of use in its crystalline state, as well as possible of ready conversion into various forms of soda-products such as soda ash, caustic soda, bicar-

bonate, and so on. In view of the immensity of the deposit and the widespread demand existing for soda in all its forms, it is not surprising that this wonderful lake is now being exploited, although, as a preliminary, it has entailed the construction of a special railway, ninety-five miles long, to bring the lake into direct touch with the coast at Mombasa, via the Uganda railway.

CHAPTER VII

Iron—The World's Friend

WHILE it is difficult to conceive the modern world continuing its activities without coal, it is far more baffling to endeavour to realise how it could possibly keep going without its supplies of iron. There is scarcely an industry into which this metal does not enter in one form or another. It is as indispensable to commerce as is bread to the human toiler. Fortunately for the world at large iron is distributed with extreme liberality over the whole of the earth's surface; it is far more abundant than coal; and there is scarcely a country in which it is not to be found. Iron is not even the privilege of an advanced civilisation, because we find ample evidences of its use by savage tribes, though in such cases its applications are distinctly circumscribed and far from being utilitarian.

It is somewhat interesting to remark how, except within the past few years, it has been so essential for these two minerals, coal and iron, to be found in close proximity to secure the full development of both. When fuel has not been forthcoming on the spot, the development of the iron ore reserves of a district has been abandoned, because the utilisation of wood for this purpose is severely limited by the quantity available in the immediate neighbourhood. We have a striking instance of this fuel influence in these islands. The county of Sussex, and part of the adjacent territory of

Kent, are rich in iron ore of high quality. For years these resources were developed, as is evidenced by the remains of the underground workings which may be traversed to-day. But there is, or rather was, no known coal supplies in the vicinity—it had to be brought from distant places. So, when the discovery of abundant supplies of ore in the north-eastern corner of the country was made, and next door to equally impressive supplies of coal, the iron industry promptly migrated from the one to the other end of the country. It has remained there ever since, although the discovery of coal in Kent has invested the southern iron situation with quite a new interest. The pendulum is destined to swing back again. There is every indication that, within the next fifty years, the south of England will become as thickly dotted with iron works as is the north to-day. The movement has already commenced.

The fact that iron must be found next door to coal to permit it to be worked no longer obtains. For confirmation of this circumstance we are able to turn to various parts of the world to observe the mining of ore with intensity and upon impressive proportions, and hundreds of miles away from any coal. For instance, thousands of tons of ore are being torn daily from the fields fringing Lake Superior, and transported the length of the chain of the American Great Lakes to the steeleries, involving transport over nearly 2,000 miles. Iron is being won from the mountains of Sweden, and the ore shipped to this and other countries. Huge works have likewise been laid down in Spain devoted to naught but the excavation of ore and its shipment to other parts of the world.

This remarkable transformation has been rendered feasible by the exercise of wonderful fertility of thought

on the part of the industrial chemist. No longer does distance of haul govern the situation. In 1913 Great Britain produced about 8,000,000 tons of steel; in 1918 the output had risen to more than 12,000,000 tons, and there is no reason why we should not turn out 30,000,000 tons a year. While a large proportion of this ore is of domestic origin, an enormous quantity is drawn from abroad. Thus, in 1913, we imported over 7,400,000 tons of ore, representing nearly £7,000,000 in value. Of this huge total 4,500,000 tons came from Spain, and over 850,000 tons from Norway and Sweden.

Iron is found in a variety of forms, and associated with a diversity of different materials. There is the magnetic variety known as magnetite, found in Sweden and other places, containing 72 per cent. of iron; red hæmatite, the ferric oxide, carrying 70 per cent. iron, having large and beautiful crystalline masses of a steel-grey colour, or large kidney-shaped nodules. This is to be found in the Cumberland district, where the veins vary in thickness from 15 to 60 feet, and also in Spain. Another variety is the brown hæmatite or brown iron ore found extensively in these islands as well as in Spain, the colour ranging from blood-red to yellowish-brown—hence the distinguishing name. Bog iron ore, which, curiously enough, is found in irregular pockets in peat bogs, belongs to this group. Then there is the "spathic" iron ore or carbonate of iron, as it is called when found in the comparatively pure and crystallised state. But it is more often found to be impure and earthy, when it is described as clay ironstone or blackband. Numerous other ores carry iron in varying degree; but in many instances, while the ore is mined and treated, the process is followed to secure the other constituent, and not perforcedly the iron.

For instance, iron pyrites, composed of sulphur and iron, are more valuable for their sulphur content; franklinite is treated for its zinc and copper; while chromium is more valuable than the iron in chromite, and so on.

Pure iron is not known in the natural state, except when recovered from meteorites—those visitors from space which occasionally reach us more or less intact. In all other instances, the ore has to be subjected to a prolonged series of special treatments and processes before the ultimate desired product is obtained, commencing with the blast furnace, which separates the iron constituent from the majority of the other minerals with which it is associated in the ore, and reducing it to a solid metallic form known as pig-iron.

The methods whereby the ore is won from the earth vary very widely according to the place in which it is found. Open workings are favoured for the most part, though in some instances it is incumbent to dig for the ore, in which case it becomes necessary to sink shafts through superimposed strata, and to drive tunnels along the lines assumed by the veins.

The world's demand for iron and steel products is so enormous and so insatiable as to have been responsible for remarkable achievements in the winning of the ore from the earth. During 1913 Great Britain, Germany and the United States produced no fewer than 58,000,000 tons of this metal. If we assume that the ore contains only 60 per cent. of iron, that is, considered from the all-round point of view, so that nearly two tons of ore are required to produce one ton of iron, we find that in order to meet the needs of the three nations in question over 96,000,000 tons of ore had to be mined during the year. To satisfy this demand huge depressions are

being dug into the face of the earth, while imposing mountains are being gradually devoured by the aid of blasting agents, ponderous steam shovels, and wonderful huge excavators which remove the earth in a steady stream by the aid of buckets travelling continuously along an endless chain carried over a projecting ladder, the buckets scraping up the earth as they move upwards.

In some parts of the world are what can only be described as massive mountains of iron ore, the removal of which is carried out upon a spectacular scale. What appear to be cyclopean steps are carved in the face of the mountain. They are terraces or benches, and upon each is laid a railway carrying a constantly and steadily moving train of cars, while another line, laid parallel to the railway track, serves as the runway for the excavating machinery. With each swing of the bucket of the steam shovel from 4 to 7 tons of ore are picked up, swung round and dumped into the trucks. The latter as they are filled are moved forward to be hauled finally to the dumping bins where the trucks are discharged. In some instances the laden cars glide down inclined railways, shoot their loads at the bottom, and travel up the ascending track, the weight of the descending cars elevating the empty vehicles to the top. Progress is maintained systematically upon each step or terrace so that the mountain is devoured steadily in one mass from top to bottom, to be carried away and passed through the blast furnaces of the world to be converted into iron and steel.

Mexico, that wonderful country of mineral wealth untold, has one of these wonderful iron mountains, the history concerning which is a romance in itself. It rears its crest 700 feet above the level of the surrounding plateau at Durango. It is estimated to contain, from the level of the valley to the

peak, no fewer than 600,000,000 tons of ore of 60 to 67 per cent. purity. This represents only the mass projecting above the plain. The continuation of the ore below that level remains merely a matter for speculation.

Another similar mountain of iron ore is being exploited at Kiruna in Lapland, which offers an interesting illustration of the open terrace system of working. Incidentally Sweden offers an interesting example of how the iron ore producing centre of the world is constantly changing. In the eighteenth century one-tenth of the whole world's supply of iron was drawn from Sweden; to-day its contribution does not exceed 1 per cent. It has been surpassed by the younger countries. Of the world's total ore production its share is approximately 3 per cent. Wood, which abounds in Sweden, and water-power, which is similarly plentiful, can no longer prevail against cheap coal. But while Sweden has been passed by the other nations, Swedish ore will always command a certain and large market. It is very low in phosphorus, that bugbear of the iron and steel worker, Dannemore iron being almost entirely free from this pernicious element.

To a certain degree technical skill has succeeded in neutralising the phosphorus evil, which is fortunate for us because otherwise the ores of Britain would never have been so extensively exploited as they are to-day. Britain's success in overcoming this enemy, thereby bringing her own ores into service, has reacted somewhat advantageously to Sweden. The Lapland ores suffer from being heavy in phosphorus, but by the employment of the methods which have proved so successful in Britain, it has been found possible to carry the development of the Lapland raw material to an advanced degree. Of the ore dug in Sweden normally

about 80 per cent. was exported, the huge works in Western Germany being the largest customer; while, on the other hand, we buy the greater part of the locally smelted pig-iron. It must not be forgotten that in addition to making huge purchases of ore to feed our steeleries we purchase many hundred thousands of tons of iron and steel in various forms, unmanufactured and partly manufactured, to be worked up into various articles of commerce during the course of the year.

Undoubtedly the most remarkable iron ore field of to-day is that being exploited in the State of Michigan, fringing the shore of Lake Superior, and which is generically known as the Superior Range. There are really four great fields—Menominee, Marquette, Mesabi and Gogebic respectively. This wonder field owes its development essentially to the energy and enterprise of James J. Hill, the American railway pioneer, who spared no effort to turn the ore there abounding in plenty into the furnaces of the United States, and, in so doing, played no small part in the amazing expansion of the American steel industry. Exploitation has been carried out upon such a huge and spectacular scale that over 250,000,000 tons of ore were taken out during the comparatively short space of 20 years, while current output is in excess of 30,000,000 tons a year, or about one-half of that used by the iron and steel works of the country.

One may not think it possible for romance to be associated with such a prosaic material as iron ore, but it is. It was accident which brought about the opening up of the great Cleveland ore district of Britain. Two gentlemen, one a chemist and the other an ironmaster—Messrs. Bolckow and Vaughan—were walking over the countryside when the chemist happened to kick a piece of stone with his foot. Its

peculiar characteristics excited his interest. He picked up the piece of stone, examined it critically, took it home, investigated it in the laboratory, and communicated to his colleague the fact that it was rich in iron. Forthwith mining commenced, and, before many years had passed, Cleveland ore had achieved a distinctive reputation in the country, while the two gentlemen who were responsible for the discovery established what is now one of the largest ironworks in these islands.

Similar romance is identified with the development of the Lake Superior range. The attractive reaches of the country were being farmed; other parts which were water-logged were being left severely alone since development work was requisite to drain the swamps. Some inquisitive prospectors, gifted with the sense of scenting iron ore, came along, probing and stabbing the soil, pushing their way into the dense underbrush, wading up to their thighs in the bogs, and burying themselves for days on end in the scrub searching for outcrops, as the points where mineral seams burst to the surface are called. When they found an outcrop they followed it up with a perfunctory test shaft and drove trenches along its run. But they found so much iron as to persuade them with the knowledge that they could very easily leave the swamp-infested reaches of the iron-bearing country alone.

One of these ancient soil scratchers, a German, had made an old sketch of the Marquette district when the presence of iron in the territory was scarcely known. At one point on this map he inscribed in German: "Here is a good place to look for iron ore." When he died his map drifted hither and thither until it happened to drop into the hands of an enterprising individual, George Maas, who set out to discover the spot. It was in the heart of a stretch of flat field at Negaunee.

Superficially there was no apparent sign of iron ore, but Maas somehow or other cherished faith in the German's recommendation, and accordingly decided to drill the earth at the point indicated on the rough and tattered map. Expert miners, geologists and prospectors ridiculed George Maas for believing such an old woman's tale. The map tickled them to death. It savoured so much of Captain Kidd and other tales of buried treasure. However, Maas was not to be perturbed. He drilled, and to the amazement of everyone drove clean into an iron ore bed which, when proved, represented 10,000,000 tons. Flushed with this success Maas launched into other drilling operations in the most unlikely districts, flouting the advice of geologists, the experience of prospectors and the recommendations of experienced miners. And time after time he made a strike, some exceedingly rich deposits of ore being revealed in this manner.

Accident and luck played a prominent part in other corners of this rich iron-bearing territory. Directly it became known that iron ore was being struck in incredible quantities all the farmers for miles around flew to the alert. They were all tilling their small patches of land, and had been more or less satisfied with the meagre returns which they were bringing. Now they saw the chance to get rich quickly, and so would have no more to do with the plough which had served them so faithfully; it was a slow means whereby to amass wealth compared with mining. Every farmer stoutly maintained that under his land was a deposit eclipsing any which had yet been found, and hung around the mining offices which had sprung up as if by magic to deal in properties, urging the representatives to put down a trial drill upon his land to see if he were not telling the truth. When the mining experts settled down to sift the representa-

tions they found that, according to the statements of the agriculturists the whole of the State must be an iron-bed, seeing that some of the enthusiastic farmers came from many miles beyond the proved area. At first the experts laughed at the claims advanced, declared them to be hopeless, and would have nothing to do with the entreaties. But the farmers became so insistent that to appease them, or rather to shatter their wild dreams of wealth very emphatically and to induce them to resume ploughing, one or two shallow drill-holes were driven, just on chance. But to the amazement of the mining experts the farmers in their ignorance were found to be correct. Some of these chance holes plunged right into unsuspected beds of ore, and in this way it was learned for the first time that the deposits really did stretch over a far greater reach of territory than had ever been thought possible.

It must not be imagined from this that all the best work was accomplished by accident, and that luck had more to do with the opening up of the country than applied knowledge in the form of geological science; far from it. Some of the richest areas were found as the result of systematic exploration, and conclusively established the calculations of the geologists. One gentleman, who had lived in the district for many years, carried out a thorough and well-ordered investigation of the whole countryside in which he resided, and proved deposit after deposit, or established the continuation of a zone from a proved point to others far distant.

When the geologist settled down to work, progress was recorded in an amazing manner. The prospectors and experts supported them, driving their drills down to great depths, in some cases to 1,500 feet. When it is stated that drilling cost about 12s. 6d. a foot, the daring character of

these deep borings may be realised, since carrying a drill down to 1,500 feet meant an expenditure exceeding £930. The drillers and explorers accomplished invaluable work proving from their operations how the layers were superimposed, and showing their peculiar twists and folds, which information not only enabled the scientific staff to prepare reliable maps, but also served to guide the expert driller in determining when and where to stop and to re-drill. In this way the concealed banks of ore were steadily and thoroughly revealed in a methodical manner. Moreover, the system followed enabled the work to be conducted in the swamps as easily as upon high-lying dry ground. In one or two instances it even enabled proving to be carried out in winter, using the ice as the support for the drilling plant, the holes of course being driven through the ice and underlying water.

The beds which were discovered in this manner were found to vary pronouncedly in thickness. Some were about 300 feet while others were found to run up to 1,000 feet or more. The geologists critically examined the material excavated from the boreholes, freely resorting to the microscope, and in this way what appeared to be galling failures, owing to the fact that the drill was driven between two beds, were often redeemed. In one instance the drill hole, which was abandoned after £800 had been spent, was found to have missed the deposit by 100 feet. The drillers were misled by what they encountered after reaching 800 feet and so gave up the quest until the geologist came to the rescue. He found that the core drawn from the drill hole was not of the nature suspected by the drillers and strongly urged them to attack the drill hole once more. They did so, somewhat reluctantly, with the result that ore was struck at 900 feet. It was the varying depth of the top stratæ which

led to the early condemnation of the Negaunee field, but which has since been proved to be the greatest in the territory. It was only the daring enterprise of George Maas, in driving his drills to greater depths than had ever been attempted previously, which clinched the existence of the ore.

Of course, after the field had once been proved, and James J. Hill had entered upon the scene, development and exploitation went ahead with rare zest. No time was lost in getting down to the storehouse of iron and, as soon as it was opened, machinery of the latest description was introduced upon an elaborate scale. Docks were laid down, with capacious bins ranged in long rows alongside, to enable the special vessels built for this traffic to receive their loads automatically and to be filled within an hour or two. It was the gigantic scale upon which the task was attacked which led to the development of an extraordinary trans-lake freight of ore traffic, a business which is restricted to only about five months of the year, owing to the lakes being within the grasp of King Winter and becoming icebound for the remainder of the twelve months. But the traffic has risen to such proportions as to render the Sault Ste. Marie canal, connecting Lakes Huron and Superior, the busiest canal in the world, rivalling even the Suez connecting link in maritime traffic; the volume passing through it exceeds 30,000,000 tons of iron ore a year.

Another extraordinary iron ore deposit has been found upon the Island of Cuba. It is virtually a mass of this mineral projecting above the sea. So far over 600,000,000 tons of this mineral have been proved, and the annual shipment has risen to about 50,000 tons but is rapidly expanding. The bench or terrace system of excavation is practised, ponderous excavators tearing out the ore and dumping it

directly into trucks. As yet this iron field is in its infancy, the preliminary work necessary being of considerable magnitude, notably in connection with the provision of a special harbour and shipping facilities. Once work gets into its stride Cuba will prove a formidable rival to the Michigan ore ranges, sea-transport of the ore, owing to modern handling conditions at the mines and ports, acting as no deterrent.

While Britain cannot point to such huge ore-beds as are to be found in other parts of the world, yet her resources of this indispensable mineral in the aggregate are enormous, and, if the truth were known, are far more extensive than we imagine, because new beds are repeatedly being unearthed. In winning the ore her undertakings are quite as enterprising as those of foreign rivals, while her mines generally speaking are just as efficiently equipped. In some instances her Fathers of the industry, to secure the ore, have proceeded to more daring lengths than have ever been recorded in other parts of the world.

Some few years ago the Hodbarrow Mining Company, Limited, whose mines lie between Hodbarrow and Haverigg and near Millom on the coast of Cumberland, discovered that the rich veins of ore extended under the sea-bed, and that the latter sections were even richer than those being worked upon the coast. Accordingly, the company decided to push its underground workings out to sea to tap this huge submarine deposit. But it was speedily learned that mining upon dry land and under the sea were two vastly different proposals. The geological formation, as it reached seawards, became somewhat treacherous. As the ore was removed from the lower levels the galleries collapsed and the danger of the mines becoming flooded from an incursion of the sea

became truly serious. To arrest the insidious penetration by salt water a timber revetment was built, more or less parallel with the line where sea met land, and in this way the danger for the time being was averted. This expedient, however, was purely temporary. It was decided to remove the hazard to life and property which the sea persistently offered, and to this end a massive sea-wall of concrete, 3,000 feet in length, was built along the foreshore, which not only assured safety, but at the same time brought 6,000,000 tons or ore within reach of the miners.

This provision met all requirements for eight years. Then unexpectedly a vein of quicksand was tapped. It ran like water, the seashore collapsed and the sea gained its victory by pushing its way into the underground workings. Every effort was put forth to arrest the encroachment of the water and to save the mine. This end being satisfactorily achieved the owners of the mine decided upon a grim fight with the ocean once and for all. The sea had endeavoured to capture the mine; the mining company decided to retaliate by pushing the sea farther back. A gigantic engineering work was elaborated to reclaim a large expanse of Duddon Sands. A huge barrier was thrown out to sweep in a broad semicircle across the bay, roping in 170 acres of sea lying between two promontories. It was a daring scheme, but it was successfully accomplished. The sea was pushed back with a barrier which absorbed 1,500,000 tons of limestone, 150,000 tons of concrete for fabricating huge blocks weighing 25 tons apiece to defy the fierce Atlantic gales which pound this stretch of the Cumberland coast, 100,000 cubic feet of timber, 4,400 tons of steel, while, to carry out the work, 25 miles of railways had to be laid and plant valued at £90,000 installed. By the time the task was completed, entailing

complete prevention of sea percolation, grim tussles with springs, and the diversion of the Swash Channel, £500,000 had been spent. But the 170 acres of reclaimed sea-bed to-day is as safe from the hungry ocean, and as dry as the surrounding mainland. It was a bold enterprise and, although the cost was enormous for a private company, they reaped their reward. By this victory over the blind forces of Nature they brought within reach of the miners and the steeleries over 30,000,000 tons of some of the finest iron ore in the country. Six years were occupied in the struggle, and it will need a furious gale and terrific wave action to break through the protective rim which has been thrown up, seeing that it measures 210 feet in width at the base tapering to 83 feet wide at the top, and is 40 feet in height, while before they breach the main protective wall the waves have got to shatter the massive flank of 25-ton concrete blocks distributed as irregularly as possible to offer the most effective breaking effort to their heavy pounding action.

The equipment of British mines, especially the underground workings, leaves little room for unfavourable comparison with those in other countries, even if it be not actually superior to general practice. Take the Loftus mines which are operated by Messrs. Pease and Partners, Limited, as a case in point. This ironstone mine, of considerable extent, really comprises three mines, one lying under the town of Loftus, the second to the north of the town, and the third about two miles distant. The mines themselves comprise two adits which have been driven into the hillside on the east of the deep valley separating Loftus from Carlinhow in Yorkshire. Here a comprehensive electrification scheme has been carried out, including the electric lighting of the underground workings, hauling, pumping and drilling.

The electric drills are mounted upon carriages which are electrically driven. The drill itself is equipped with a 5-horse-power motor with a sufficient length of cable mounted upon a drum to allow independent free movement over an appreciable radius of action. Each drill, working on the rotary principle, is capable of driving 30 holes, each 1½ inch in diameter, to a depth of 3 to 4 feet in an hour. Then there are powerful little pumps, likewise electrically driven, mounted upon low carriages similarly electrically propelled, which can be moved about the mine to cope with the water. The pumping capacity of each portable outfit ranges from 50 to 90 gallons per hour, and these suffice to keep the mine drained. The water thus handled is delivered to a sump, whence it is discharged to the surface by larger and fixed centrifugal pumps which are able to lift the water to a height of 300 feet, and to discharge it at the rate of 600 gallons a minute. The whole of the haulage is carried out by electricity upon the endless rope system, the rope having a travelling speed of about 1½ mile per hour. By means of this system from 30 to 50 tons of ore per hour can be moved and, bearing in mind the roughness of the road traversed, the travelling speed and load are eminently satisfactory. It is an interesting illustration of the possibilities of electricity as applied to English mining, but may be said to be typical of the country, and suffices to prove that, in point of mechanical aid to mining, we are equal to our competitors, although the smaller scale upon which the industry is conducted, coupled with the necessity to dive underground for the ore, does not conduce to the utilisation of the huge tools incidental to the industry as practised in other parts of the world.

It is doubtful whether the average individual has any true

conception of the dimensions of the British iron and steel industry. The magnitude of the big corporations incidental to other countries where the "Community of interests" principle is carried to an advanced degree, notably the gigantic steel corporation of the United States, rather tends to dwarf operations in these islands. But, if the whole of the iron and steel works scattered throughout Britain could be brought together to form a single entity they would completely eclipse the American concern. Financially they would be hopelessly out-distanced, but this is due to the sounder methods practised by their iron and steel masters. The capitalisation of British companies offers no true index to their wealth or value or comprehensiveness of their plant. Thus, one of her foremost companies has a capital of only £600,000—a small sum indeed besides the millions of capital requisite to operate the American plant. But the value of the installation and equipment owned by the British company exceeds £2,000,000, which is equivalent to more than three times the capital. It is the individualism incidental to her industry which militates against a true impression of its actual magnitude being formed by the lay mind. But the fact that we have to import several million tons of ores to keep our works going, in addition to the millions of tons of local ore annually consumed, should be adequate to show that our iron and steel working trade is one of vast extent and considerable importance.

CHAPTER VIII

Tin

OF all the treasures of the earth which have contributed to Britain's industrial wealth none has played so prominent and ancient a part as tin. It was the product of these islands to establish international trading, for did not the Phœnicians come to this country for their supplies of tin, and that long before the introduction of Christianity?

Accordingly, this metal may truthfully be described as the foundation stone of our wealth and trade, while the mines identified with this phase of activity are by far the most interesting, not only in the United Kingdom, but probably in the whole world. Furthermore it is an industry in which science has been able to make only little headway. Some have endeavoured to bring the equipment and operating methods into line with contemporary practice, but it is a complex and abnormally expensive undertaking—one from which the ultra-scientific mining engineer has been known to shrink, his exuberant enthusiasm notwithstanding, after inspection of the problem in all its intricate bearings at close quarters. In view of the situation, therefore, it is not surprising to find the old ways still reigning supreme, which invests the industry with a peculiar fascination. But, if the mines do not conform with modern ideas for the conduct of such work, they have certainly produced the finest type of miner, "Cousin Jack," as the Cornish tin miner is colloquially

By permission of the Malay States Information Agency.

"PAY-DIRT" IN A MALAY TIN MINE

In the Malay mines the workmen lift the "pay-dirt," containing the mineral, by means of long-handled buckets, which they carry up from the mine by steps.

called, being in keen request the whole mining world over.

Tin is one of those metals which Nature has not distributed with a free hand. Seeing that it has come to be recognised as indispensable to commerce, the circumstance that it is recovered by generally accepted old-fashioned methods enables such to be pursued with profit. The fluctuations in the price of the metal have been wide, varying from about £60 to £320 and more per ton. The latter may be said to represent an abnormal high-water mark, but it is doubtful whether the metal will ever again sink to a low level, unless other tin-bearing supplies become revealed, because the metal to-day is in more urgent request than ever. The extraordinary development of the food-packers' handicraft has been mainly responsible for this tendency towards high prices, tin, as yet, having proved to be superior to all rivals for this purpose, although it enters into the preparation of the vessel carrying the cooked product to the degree of only one per cent., and this in the form of a thin film or coating to the iron base. This metal has the peculiar virtue of resisting the acids peculiar to foodstuffs of every description—hence its use.

The British industry is centred in Cornwall, that county of rugged granite coast-line so forbidding to mariners; but the granite which is so feared by one section of the community represents wealth to others, because the tin is associated with this stern, dense and hard rock. The veins or lodes are rich, and for the most part run in a north to south direction. The extreme density and hardness of the rock offers a stern resistance to the tools wielded by the miners so that progress is relatively slow, despite the evolution of special tools to deal with this geological formation. The

exasperating hardness of the granite, however, is not without its compensations. The miner is spared many of the menaces to which other underground workers are exposed. The risk of collapse is not pronounced, and timber shoring, though practised, is not carried out to the extent incidental to other mining operations. The mines are of extreme depth, the deepest being the Dolcoath, which has its lowest level at 3,600 feet below the surface of the surrounding country.

Dolcoath is one of the most historic mines in the district. To traverse the whole of the galleries radiating from the main shaft at various levels would entail an inspiriting walk of nearly 100 miles. Within the course of a century approximately 6,000,000,000 tons of black tin were removed from this one mine alone, and this represents only a minute fraction of the wealth still associated with the granite which it traverses. Consequently Dolcoath is far from being worked out.

Upon the surface there is ample evidence of the activity which has been steadily pursued three-quarters of a mile below one's feet. Huge desolate mounds of slaty-coloured rubble surround the mouth of the shaft on all sides. This is the spoil removed from the mine—the tailings from the tin ore.

The shaft of the tin mine varies from that associated with other mines in many respects. In the first place it is probably unique in its design. That at Dolcoath is not vertical, but set at an angle to the vertical. It is divided into two passages by a partition, one serving as the highway for the men passing up and down, while the second is the passage through which the ores are borne to the surface. At the points or levels where the shaft passes through the tin-bearing

veins, adits or tunnels are driven, following the line of the vein. The miners descend in a "gig," a curious kind of cage somewhat resembling a shallow box, and accommodating three or four at a time. Another curious feature of the mine is the "man" engine, a kind of inclined conveyor with projecting shelves at intervals upon which the man stands, and is thus lifted from level to level. The tin-miner follows the practice which has obtained for almost more years than one can remember. Before entering the mine he takes a lump of moist clay in which he inserts a candle, and plumps the combination upon the peak of his hat, thus converting his headgear into a candlestick. This is to light him during his tramp of the gallery in which he labours, and the rock face upon which he is engaged in wresting the tin from the fastnesses in which it has been imprisoned for centuries. It is not a brilliant illumination, but it has so far proved to be superior to all others for the character of the task followed. In the tin-mine, even in the lowest depths, the miner is spared all the dangers incidental to the fiery coal-mine, and so a naked light may be carried with impunity.

As may be imagined, owing to the density and hardness of the rock face, recourse must be made to the drill and the savage disruptive powers of high explosives to tear down the metal-bearing ore. Drilling is a tedious task, the rock putting up a stiff fight against the rotating or hammering chisel. When the hole has been carried to the desired depth an explosive charge is inserted, fuse attached and the hole tamped. When all is ready there is just the one-word signal "Fire!" It does not announce the outbreak of a conflagration, but the fact that a blast is being made, and all the miners in the vicinity promptly scuttle to a point of safety. "Firing the hole" disintegrates the rock, allowing it to be brought

down by hammer, chisel and pick. It is shovelled into little trolleys or skips to be pushed by men themselves, or to be hauled by ponies to the main shaft, and thence borne to the surface for treatment. Blasting is practised extensively, although the individual shots are relatively small, being designed to accomplish the required work and no more; about £20,000 worth of explosives is used every year.

The intricacy of the galleries is somewhat amazing, and the visitor to the mine may be astonished that the miners are able to find their way about the deep subterranean caverns which they have blasted and hewed so readily. The cross-cuts are frequently driven with no more aid than that offered by a compass, and often a connecting passage is cut simultaneously at several different points, to be connected up to form one continuous passage, and also to the shafts. It is work which requires unerring exactitude, but the perfection with which it is carried out with only the guidance of the compass testifies to the high degree of skill possessed by the Cornish miner.

While fire-damp and choke-damp are dangers from which the tin-miner is immune, he is assailed by another enemy equally to be dreaded. This is water. True, it assails all underground workings without fear or favour, but somehow or other it appears to be most manifest in the tin-mine. The danger to be dreaded in this connection is accentuated when, as in the Levant mine, the transverse galleries have been driven out from the coast under the bed of the Atlantic in quest of the ore. The most distant point of the underground workings in this mine is about a mile out to sea. In this instance the water trouble is pronounced, there being only a relatively thin skin of rock between the working and the open

ocean, and the water flows through the fissures in large quantities. One may marvel at the temerity of the miner in driving his galleries within close reach of such a relentless enemy as the Atlantic, and wonder why he does not confine his endeavours to safer quarters. But the tin drawn from under the sea in this instance is well worth the winning, the vein being not only rich in tin, but in copper and arsenic as well.

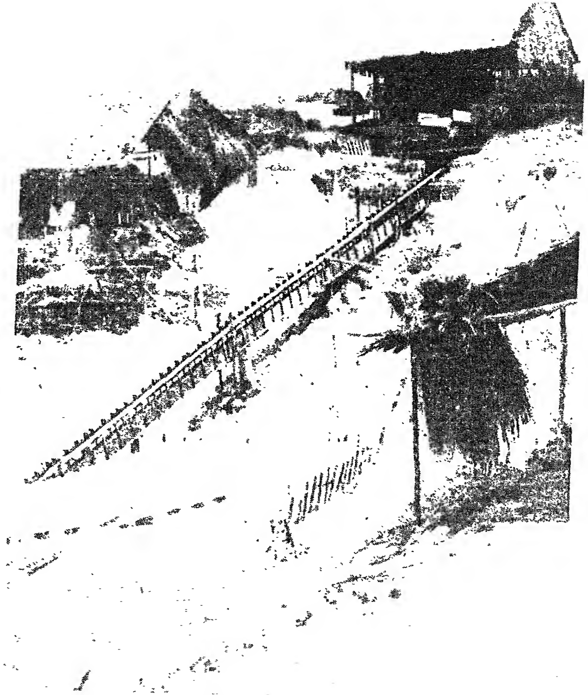
In some of the other deep mines the workers toiling laboriously at an extremely low level are called upon to wade in a thick slime. The existence of the water and mud, while inconvenient and decidedly uncomfortable, in themselves do not represent the worst feature of the conditions encountered. The tin is heavily associated with arsenic. This combines with the water and the atmosphere, and is mainly responsible for that scourge known as miners' phthisis, with which Cousin Jacks are so freely assailed, and to which such large numbers succumb.

Of course, it may be argued that the installation of efficient pumping machinery and drainage facilities would enable the water fiend to be kept well in hand: but this is impossible. Elaborate plant is laid down to cope with the evil, while the methods followed by the miner are such as to reduce its significance to the minimum. A gallery is generally driven at a slight inclination, a small sump or dip being left at the foot of the bank to receive the water running into the gallery, and from which depression it is lifted to the surface. Pumping in the Cornish mines is carried out upon a big scale, some of the mines being replete with facilities capable of lifting 1,600 gallons a minute to the surface to expend itself harmlessly. During the course of the year well over 40,000,000 tons of water—about 9,000,000,000 gallons—

are pumped from the Cornish mines, to drain back into the Atlantic.

Heat is another antagonist against which the miner is compelled to contend, and it is heat indeed when working in the lowest depths such as the 3,600 feet level of the Dolcoath Mine. Clothing has to be reduced to a negligible quantity, and the men work stripped to the waist. Even with ventilation carried out as perfectly as human ingenuity can contrive the atmosphere is sultry, and it is accentuated to a certain degree when explosives have to be used extensively. The men present strange looking pictures, their bodies covered with dust cut into weirdly fantastic designs by the runnels of perspiration pouring in endless streams from their bodies. In fact, the heat encountered is so exacting that stalwart miners have been known, at times, to lose four or more pounds weight during a single six hours' shift! It has been dissipated in the form of perspiration. Little wonder that the Cornish miner is always envied because of his physique. It must be of an abnormal quality to withstand such a strain as that to which it is subjected in a deep tin-mine. The necessity for complete and adequate ventilation may be realised from the circumstance that the mercury in the thermometer is scientifically declared to rise at the rate of one degree Fahrenheit for every 60 feet of descent into the earth, which would bring the temperature to be expected in the lowest level of the Dolcoath Mine to 360 degrees! Water boils at 212 degrees Fahrenheit, although it must not be forgotten that as we descend the boiling point of water rises in proportion to the increase in the barometric pressure, the boiling point at 2,100 feet in the depth of a mine, with the barometer standing at 32·13 inches, being 216 degrees.

Not a glacier, but a huge lake of "tailings" from which the particles of tin ore have been recovered.



Photos. by permission of the Malay States Information Agency.

Pumping water by native designed and fashioned methods. In this work the Chinese coolie is ingenious.

WINNING TIN IN MALAYA

Tin

In former times of prosperity the miners were either able to obtain such sufficiently attractive prices for their products, or the "vanning" process was so incompletely performed as to permit an appreciable quantity of the black tin to escape. Be that as it may, a certain proportion of the Cornish tin workers have found it profitable to participate in mining in another way. A stream runs into the sea. It is known as the "Six Miles." At suitable points throughout its brief run, where the conditions are favourable, a variety of washing systems have been established by men known as "streamers," and they treat the tailings from the "vanning" tables, as well as the contents of the straggling dumps—the accumulation of years from the mines. Submission to water treatment under possibly more modern and diligent conditions enables a lucrative yield of black tin to be recovered in this manner, and the disposal of the output from the streamers alone has been known to realise as much as £60,000, or more, per annum.

"Streaming" for black tin in Cornwall revives memories of the process practised extensively in Malaya. The Cornish tin held the world's markets until the opening of the reserves of this metal in the Malay Peninsula. Here the tin is not only abundant, but it does not demand driving through hard granitic rock with free use of explosives to advance but a few inches as it were at a time. Malaya tin is recovered for the most part from alluvial deposits, and has been distributed so thickly as to render the recovery exceptionally attractive. Moreover, the labour required for recovering the treasure is both plentiful and cheap.

When Nature, in one of her tumultuous moods, decided to mould this part of the world she did not hesitate to flout all precedent, and, as a result, has confronted the geologist

with some pretty departures from the orthodox. This is emphasised very vividly in connection with tin. At Lahat is or was an interesting geological curiosity. Instead of the tin being distributed in veins and lodes in granite, a column of tin ore about 25 feet in diameter was found buried in a mass of limestone. It is not set quite vertically, but nearly so, and nearly 100 feet in depth. But the ore was packed, or rammed, so tightly into this hole in the limestone by natural influences, as to require crushing, and when assayed was found to average 747 pounds of black tin per ton of ore crushed.

It is, however, the alluvial deposits which carry the tin wealth of the peninsula, and incidentally it is the field which not only yields richest prizes, but which offers employment to thousands of men, women and children. The Tronoh Mine has one of these alluvial deposits of great depth. The testing drills have been driven down to depths of 160 feet or so without touching bottom. This cavity carries sand and gravel, with which tin is associated to the extent of about 1½ pound to the 100 pounds of alluvium. In this instance it is only too evident that the tin has been extracted from the adjacent granitic rocks by the eroding forces of Nature, and washed down with the detritus to fill the cavity. Of course, all the tin which is now recovered from the alluvial deposits at one time or another was shackled in the granite, but Nature has been very busy in disrupting her moulding work at this point, grinding and milling the rocks in her own inimitable manner through the passage of centuries, and then carrying the dust by storm water into the depressions, where it has settled into immense tracts of deposits.

The alluvial mining of tin in the Malaya is largely in the hands of the Chinese—both master and man—and

although the Celestial appears to have a supreme contempt for the mechanical contrivances devised by Western civilisation to displace manual effort and to hasten tasks, it must not be thought that he is deficient in ingenuity to suit his own purposes. The Chinaman was an engineer when the rest of the world was living in caves; when its knowledge of minerals was confined to stone hatchets. Moreover, the Chinaman appears to have a gift for the work. Even the unsophisticated labourer, contemptuously dismissed as a coolie, and who is admitted to represent the lowest rung of the Chinese social ladder, reduces a British or American labourer to the level of an aborigine when it comes to getting down to big problems with either very slender resources or none. So far as Malaya is concerned the visitor from the enlightened West may be pardoned for expressing wonder that those concerned rest content with manual efforts when marvels of mechanical ingenuity have been evolved in Europe and America to wrestle with just such problems as obtain in this region. But the mining engineer planted in Malaya has learned many things since he first set foot in the peninsula, and if you can give him a machine which will work tin cheaper, better and as efficiently as the Chinaman with his apparently crude devices, he will adopt it.

The Chinese coolie may be expert in the use of only one tool—the axe—but he can do as much with this single implement as a mechanic might possibly accomplish with a hundred and one different machines. He has a supreme contempt for nails and screws. He can do far more with a wooden joint; while to suggest the use of wire for binding purposes would provoke him to hilarious mirth when he can secure a supply of some natural binding material such as the

indigenous rattan. Then the coolie is generally painted as being a hard-working individual, who depends upon muscle and brawn to eke out a bare living. Never was there a greater fallacy. He will never bestir himself to the movement of a finger if he can impress some natural force into service.

A visit to a Malaya mining-camp reveals the ingenuity of the Chinese coolie in a very convincing manner. There in his chain-pump, fashioned entirely from wood, every part working as smoothly as if made by machinery, wherewith water will be delivered in a steady stream up to a height of 20 feet or so, the requisite power being delivered through an ingeniously small overshot water-wheel. Then there is his water-lifting wheel, an impressive looking structure when seen from a distance, but which upon close acquaintance resolves itself into no more than a wonderful creation of bamboo poles, without a single piece of hardware entering into its construction. It works upon the undershot principle and will lift water up to a height of about 40 feet. Equally ingenious are the means adopted for lubricating the parts exposed to friction. The coolie does not resort to oil and grease, but just feeds a tiny trickle of water to the point in question and that will do the work as well as can be desired. The young engineer, coming from the West, at first sight will wonder why what he calls a "proper plant" is not put in. It would never pay. The water-wheel will last just about as long as it will pay to work the area of ground where it is installed. Then it can be permitted to fall to pieces. And although it looks a complicated structure it will be built in less time than would be required to assemble a permanent structure of metal.

Working the alluvium is carried out along primitive lines.

The simplest form is that known as *lampan-ing,* from the name of the simple ground sluice, or lampan, into which the alluvium is moved by the simple process of hoeing. The Malays and Chinese resort to this system very extensively, especially in the small and restricted areas, where, however, the yield of tin is generally somewhat high. The work is usually carried out upon a tribute scale, the toilers paying the owner so much for the right to work the alluvium, the tribute being in the form of a royalty upon the value of the mineral thus won.

Then there is the open-cast working or *lombong* as it is termed. This is a shallow open pit very rarely carried down beyond 30 feet. The water which naturally drains to the bottom of the hole is removed by means of the Chinese chain-pump, while the spoil is shovelled into baskets and carried out of the pit to be dumped into the washing-machine. In selecting his claim the Chinaman is not only astute but daring. He knows that the richest pay-dirt is to be found on the bank or bed of a stream, this being Nature's sluice for bringing down the ground and milled mountain to the lower lying parts of the country. Consequently the coolie does not hesitate to divert the course of the river when he thinks it is advisable, although the means for holding the water in its new channel might provoke shudders in Western minds, seeing that as a rule the diverting wall is naught but a clever fabrication of bamboos deftly laced together to form a fence!

But the Chinaman is not content to be merely the slave. He is quite competent to be master as well, and some of the largest and richest tin-workings in Malaya are owned by Celestials. Then one sees operations conducted upon a big scale with coolies swarming the mine as densely as ants in

an ant-hill, while the mine is criss-crossed with a bewildering maze of runways and diverse bamboo structures. In such a mine native engineering ingenuity to cope with water is superseded by Western ideas, this fiend being kept under control by steam plant and pumps. While the Chinaman is supreme in working small claims, where it would never pay to instal machinery, he is quite out of his element in operating the big open mine. The *lombong* is essentially the mine for machinery. It not only enables more pay-dirt to be handled within a given time, but also enables recovery to be carried out more efficiently and, at the same time, allows the alluvium to be worked to a far greater depth than is now possible. Moreover, in the *lombong* as much tin is discarded in the tailings, owing to absence of efficient reclaiming methods, as is actually recovered. Consequently, we may yet see the complete triumph of machinery over even the ingenious and resourceful Chinese coolie when the true import of the present wasteful method is appreciated, and when economic reasons demand that the tailings shall again be passed through the tin-winning mill.

Washing, sluicing, or panning for tin does not represent the only method honoured in this country. Tin-bearing hillsides are being honeycombed with shafts and galleries, while in some districts the hillsides are being washed away bodily by the aid of powerful streams of water projected from monitors—hydraulicking, as it is called. These modern methods owe their introduction and use to energetic and enterprising British engineers, who are not content to abide by traditional practice, and to whom the capabilities of a mine are not governed by the numbers of men figuring on the payroll, but to the volume of output, value, and the width of the margin between working expenses and profit. Mountain

streams and freshets are being tapped and harnessed, the water being led through miles of piping from the high to the lower elevation to feed the monitors, which are really powerful and specially designed nozzles. When the jet of water is flung against the friable hillside it delivers a powerful blow which is able to break up the material and to bear it away in the escaping water, the run of which can be controlled to lead the pay-dirt to the points where it is required. When the hillside is intensely hard, and the jet of water fails to effect the requisite erosion, explosives are brought into play to move the mass, and the water does the rest, the mud then freely flowing to the sluice boxes.

There is no doubt that, owing to the increasing demand for tin, not only for use in a straight form, but to cover iron plates for the satisfaction of the ever-growing food-packing trade, for the manufacture of vessels and tin-plating in general, and for the preparation of alloys, in which direction marked enterprise and research are being manifested, the exploitation of the tin resources of Malaya will need to be taken over by the men who are prepared to harness science freely to the industry. The day of the Chinaman is passing. Hitherto he has reigned supreme for many reasons. He has been specially favoured in acquisition of the tin-bearing land, and has been immune from all legislative measures in regard to sweating his labour. Moreover, in his astuteness, he has roped in the areas most easy to work, and for the minimum of initial outlay. These are becoming exhausted, and he is not prepared to venture into the less attractive areas because the outlook is not sufficiently promising. He is quite prepared to let the British mining engineer assume these risks.

More than one of the Chinese workings have been taken

over. Thus the Pahang Corporation is working a mine which had been continuously operated by Malays and Chinese for over 100 years upon the ordinary open-cast system, some of the excavations being nearly a quarter of a mile in length by 200 feet wide and 150 feet deep. They were worked just so long as it paid to do so, and they offer an interesting illustration of the wasteful methods pursued by the Chinese owner. The latter has a rooted objection to carrying out any preliminary work. He must see revenue accruing from the moment the first shovelful of earth is turned. If a streak of paying dirt is struck it is followed feverishly until it peters out. Then it is abandoned. No attempt is made to ascertain whether or no the lode has been interrupted by a fault as is often the case. Or, perhaps, the lode was worked down until the depth attained demanded the introduction of timbering. But such protective work is regarded as wasted expense by the Chinese owner, and so operations are transferred to another spot.

To a certain degree superstition has played its part in preventing the workings from being fully exploited. Under Chinese management the use of explosives was sternly forbidden lest the sound of the explosive frightened the tin away! The washing system was also found to be woefully inefficient, the tailings upon examination being found to carry as much as 7 per cent. of tin oxide, the whole or at least the greater part of which might have been recovered by the display of a little more effort and the use of crushing machinery. Then the Chinaman, while an excellent labourer in soft ground, cannot wrestle with rock. This fact has been proved not only in mining, but in other branches of engineering, such as railway building, where the coolie invariably cuts a very

sorry figure, and where his low wage does not offer any compensation for lack of efficiency.

Another reason why the Chinese employer is certain to disappear is the increasing cost of his coolie labour. In the Malay tin-mines, as in every other ramification of industry, wages are on the up grade. The coolie is refusing to be sweated so heavily as has been the case in the past. He prefers to work under the British engineer. The combination of white supervision and Chinese and Malay labour appears to be eminently satisfactory, for the simple reason that the British engineer gives a square deal, and the native knows full well that, if he carries out his work satisfactorily, he will receive his due reward. All work is done under contract, a schedule of prices to be paid having been drawn up for every conceivable operation. The contracts are let to a "boss," who is instructed beforehand precisely what he must do. The "boss" arranges for his own labour.

In making these bargains the white man has to be uncannily alert, because the Chinaman acts up to his reputation of being wily and deep in all ways that are dark. For instance, drills naturally become blunted from constant chugging at the hard rock. The custom was to levy a charge for re-sharpening, but it was found that sooner than incur the expense for such work the Chinese contractor would permit his gangs to use implements which were hopelessly blunted, and so valuable time was wasted, the rate of progress in drilling naturally falling off very markedly. This paring policy was checked by the company undertaking to sharpen the tools free of charge to the contractor, who, consequently, can never advance the excuse of "blunt tools" as a valid reason for slow progress. Again, the ore delivered to the crushing machinery or battery stamps must be of a certain

quality: its tin content must never fall below a certain level. Quality is determined previous to subletting the contract from the assays which the experts have carried out. If the ore falls below the standard the contractor does not receive a cent for any that is deficient in quality. This appears to be a drastic ruling, but it effectively prevents the contractor slipping in waste to swell his total delivery, upon which, of course, his payment is based.

The Malay Peninsula represents the richest tin-mining country in the world, its production being larger than any other individual country. Consequently its output, and the cost thereof, exert a decisive influence upon the price of the commodity. It was the severity of this competition which accentuated the ill-effects arising from the depression in the industry in Cornwall many years ago, since obviously it is possible to secure the tin by washing with cheap labour—output being governed merely by the number of labourers employed—at a lower cost than is feasible when it is necessary to descend into the depths of the earth and to wrestle with the hard granite by drill and explosive.

But while Malaya contributes approximately one-half of the world's tin South America comes second, the Andes in Bolivia being the main source of supply. The mines, which for the most part are exploited for tin, lie within four broadly defined districts and were formerly exploited by the Spaniards, not for the lustrous metal of contemporary commerce, but for silver. But the Bolivian districts suffer from extreme lofty situation coupled with somewhat remote distance from means of railway communication. The mule and llama constitute the medium of transport. Such slow movement tends to inflate costs and to restrict output, since the carrying capacity of the animals is naturally limited.

Moreover, many of the mines are deficient in modern machinery, a result due in the main to the difficulty and expense of taking up heavy and cumbrous mechanical appliances. Consequently, the back of the toiler, to-day as in the time of the Spanish occupation, constitutes the usual medium of moving the ore from the workings to the surface. Seeing that in the deeper mines a man cannot make more than two journeys a day and cannot bear more than three-quarters of a hundredweight upon his back, the volume of ore moved to the surface is naturally very meagre, more especially as labour is somewhat difficult to procure.

In some districts, notably Oruro, water constitutes the great problem, not because of its abundance as in the mines of Cornwall, but owing to its scarcity. Thus it is impossible to treat the ores on the spot. In one or two cases the ores have to be carted from 10 to 20 miles, which reacts somewhat severely against rapid development. The extremely high altitudes at which many of the mines are situated constitutes another adverse feature. Those of La Paz, driven into the flank of the Chorolque Mountain, are at 18,000 feet above the Pacific Ocean, the works where the ore is treated being 2,000 feet lower. Communication between the two is maintained by a wire ropeway. The winds experienced in this part of the country constitute a decidedly adverse factor, communication between the mine and the works often being interrupted from cars being blown off the line, while the electrical storm disturbances are also of striking severity. Here one sees an application of the Cornish "streaming" practice, private individuals working the detritus torn from the mountain sides by the forces of Nature, and submitting them to treatment in an adjacent water supply. But though

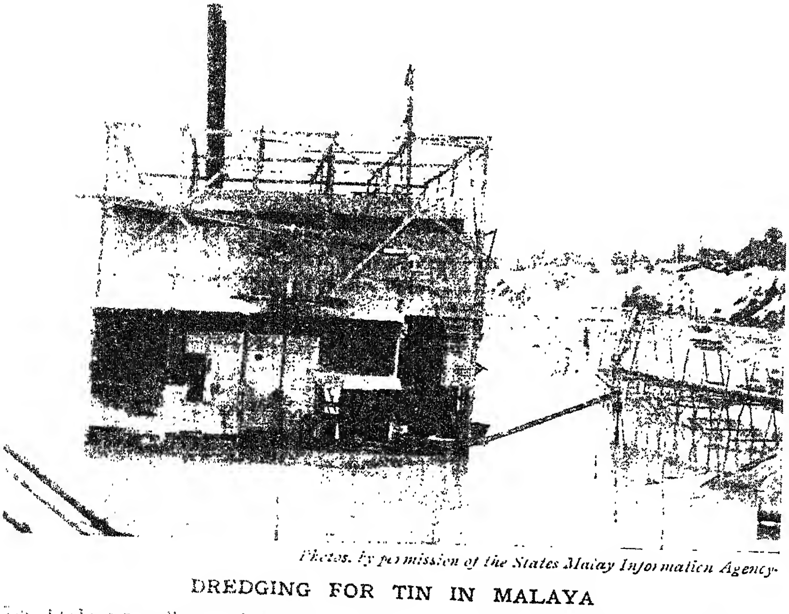
this pay-dirt is remunerative it cannot be worked for many weeks, because the water is frozen for more than half the year.

With improved means of communication, and the installation of modern machinery and under British supervision, the tin-mines of Bolivia could be rendered some of the richest in the world. Although the atmosphere is rarefied at 16,000 feet, Britishers soon become accustomed to it, as likewise to the caprices of the climate, which are violent. At midday the sun may register 70 degrees Fahrenheit. Twelve hours later the mercury will show 10 degrees of frost. From May to August the cold is intense, the thermometer often showing a reading below zero. Fuel is difficult to obtain and is costly. Charcoal and llama dung are freely used to feed the furnaces, such as they are, for the simple reason that coal costs about £10 per ton. This high charge is mainly due to the railway charging double rates for all material handled from the coast since, upon the inland run, the costly tedious climb across the Andes has to be made; on the other hand, the journey to the coast is down-hill for the greater part of the way.

During the past few years Australia and Tasmania have devoted attention to the winning of tin. In New South Wales the greater proportion is obtained by recourse to dredging, while in Tasmania it is won for the most part by the aid of monitors. The tin is found in what are called drifts of coarse quartz sand which is washed down through sluices, the heavier black tin settling out, allowing the lighter material to pass on its way. At the Briseis Tin-mine, one of the most important in the country, the water for operating the monitors is brought a distance of 30 miles through a race, or flume, about 24,000,000 gallons being received and

NATIVE TIN MINING IN MALAYA

[illegible] is the hillside of alluvial deposit, showing the various layers of earth.



Photos. by permission of the States Malay Information Agency.

DREDGING FOR TIN IN MALAYA

[illegible] alluvium is sucked or baled to the surface to permit the mineral to be recovered.

used every day, this supply of course not only feeding the monitors but the sluicing and other plants as well.

Another important tin-mine in the island is the Mount Bischoff, which was found by a gold prospector in 1871. Attracted by the dark ore lying in the bed of a creek he carried a sample nearly 60 miles to have it investigated, thinking that perhaps after all it might contain gold or silver. To his disgust he learned that it was tin ore. However, the following year the recovery of this treasure was undertaken by another party, but, at that time, it was a pretty daring adventure, seeing that the field was covered with a dense scrub, and that all supplies had to be taken over a rough track, the cost of haulage being about £30 per ton. But subsequently a narrow gauge railway took the place of the road, and in this way cost of freighting was reduced to £3 per ton.

In this instance the development work was somewhat formidable. Water was required, and so it was decided to tap the Waratah River. Huge reservoirs, capable of containing 490,000,000 gallons, were built. Such a reserve is essential, seeing that this commodity is used at the rate of 40,000 gallons an hour for various purposes. The ore is recovered in some instances from open workings by day labour, and is subsequently crushed and pulverised before being passed through the recovery plant, which is of a most efficient character to ensure the utmost quantity of tin being recovered from the ore.

During the past few years the search for tin has been prosecuted with accentuated energy, and new sources of supply are constantly being discovered and opened up. In this way we have secured further additions to the world's supply from places as far apart as Greenland, Alaska,

Siberia, Nigeria, the Congo and Japan. China, as might naturally be supposed, contains supplies of this valuable mineral, but its contribution is somewhat an unknown quantity, as are also the extent of its resources. Yet, notwithstanding the enterprise and initiative which are being displayed, there are no signs yet of demand being overtaken. Tin still remains one of the costliest everyday metals of contemporary commerce.

CHAPTER IX

The First Metal to be Used by Man?

WHICH was the first metal to be used by man? This question has proved a theme for many interesting discussions, and although it is impossible to express any absolutely definite pronouncement upon the point, yet it is generally conceded that all available indications point to one special mineral being entitled to this unique distinction.

The metal in question is copper. For some time there was a tendency to doubt whether this metal was really entitled to premier distinction in this connection. We know the "bronze age" ruled for a time, but bronze is an alloy of copper and tin. So it was felt in certain quarters that tin might possibly have preceded the use of copper, especially as we have infallible record of the ancient trading with Cornwall for supplies of this metal. But all doubts were set at rest by the discovery of weapons, far antedating the bronze epoch, made from unalloyed copper. The prehistoric peoples who resorted to this mineral for the fashioning of more effective weapons drew their supplies from a small island in the Mediterranean, the name of which is certainly familiar to the average person from its peculiar habit of popping above the political horizon at awkward moments—Cyprus—and from which the metal in question receives its distinctive technical name *cuprum*.

If copper were deemed to be indispensable to the early

races of mankind, it is far more essential to contemporary civilisation, and the demand therefore is persistently and rapidly increasing. This is due in the main to the wonderful developments during the past few years in connection with electrical engineering, copper being an ideal conductor for this form of energy. As a matter of fact, it is only excelled in this respect by one other metal, silver, but the cost of the latter militates against its general use in this field, while, so far as electrical conductivity is concerned, copper is but slightly inferior to silver. Like the latter metal, it is also an excellent conductor of heat, and its uses in this field vary from the fabrication of utensils for household purposes to the equipment of steam engines and other vessels where heat is required. To emphasise the effect which developments, especially those associated with electricity, have exercised upon the demand for copper, it may be remarked that, whereas in 1904 the world's total production of copper was 583,517 tons, in 1914—ten years later—it had nearly doubled, being 1,018,395 tons, while the present production is in the neighbourhood of 1,250,000 tons a year. Of this commodity in various forms Great Britain purchases about 257,000 tons a year, incurring an expenditure of over £11,000,000.

Of the world's total output approximately one-half is furnished by the United States of America. Great Britain can point to but slender proved resources of this mineral, although she requires it so urgently to maintain her trade, but other countries are far more happily situated. It abounds in Canada, especially in the great North-West, the thresholds to the stores of which have been barely crossed. In the United States there are vast deposits, while the other countries forming the great American continent are also rich with copper, some of the mines having been continuously worked

for hundreds of years, although, for the most part, the ores have been exploited for the other minerals which they contain, notably silver. Australia is also a large copper warehouse, and Tasmania possesses one of the largest copper-mines south of the Equator. Asia is liberally endowed with this mineral, while Africa is proving a surprise in this connection. It is relatively a young country, the interior has barely been unlocked, yet there has already been brought to light a copper-field which gives every promise of exceeding in value and output the largest proved areas in the United States. Consequently the world is not likely to experience any dearth of copper. As the demand increases there will be an additional incentive to prospect for further supplies, and to develop the producing facilities of the known fields to a far greater degree than has yet been recorded. The possibility of any one country being able to establish a monopoly is extremely remote, although it is quite possible that one or two producing centres, notably those in Africa, where abundant cheap native labour can be obtained, may be able to assume a dictatorial position in regard to price, and thus secure an indisputable autocratic position.

While the mineral is so abundant, there are many enormous areas where the ore is of such low grade as to render its profitable recovery problematical. Here and there mines are in operation, the ore from which carries less than 2 per cent. of the desired mineral, but, generally speaking, such ores are not being exploited very extensively. Other fields can offer more attractive ore, and consequently are claiming greater attention. Furthermore, in many instances the ore is impregnated with other minerals which are more profitable, so that the recovery of the copper really coincides with the utilisation of a by-product.

Copper is very rarely found in a native or pure state, the outstanding exception being the huge Calumet Mine on Lake Superior. Here, in 1859, the miners came across a huge solid chunk which they set to work to remove. A whole year was occupied in the task and gave steady occupation to forty men. When removed it was found to weigh 500 tons. Seven years later another huge lump was unearthed which turned the scale at 800 tons, and this is the largest single block yet found. For the most part the copper is found associated with other minerals. Copper ores, so called, are of wide variety, the copper being present in the form of an oxide which, however, is readily recovered. Some of these ores carry the copper oxide in company with sulphur, antimony, iron, gold and other minerals as well as various impurities. The recovery process is somewhat elaborate and is conducted in accordance with one of two broadly distinctive methods. The one known as the dry process is either by reaction or reduction; the second is the wet method, one phase of which entails the employment of electro-chemistry. The dry reaction process might almost be compared with the production of pig-iron by means of the blast furnace for the recovery of iron from its ore, although the simile is not quite appropriate, seeing that the smelting of the copper is somewhat more intricate. The wet extraction process is used for the treatment of poor ores, more especially the residues resulting from the treatment of iron pyrites to recover the sulphur, the residues carrying a certain proportion of copper being roasted with common salt, the copper thereby being converted into a chloride and subsequently precipitated by scrap iron. This process is sometimes described as the precipitation process. The copper which is thus secured is then passed through the furnace to be refined. The

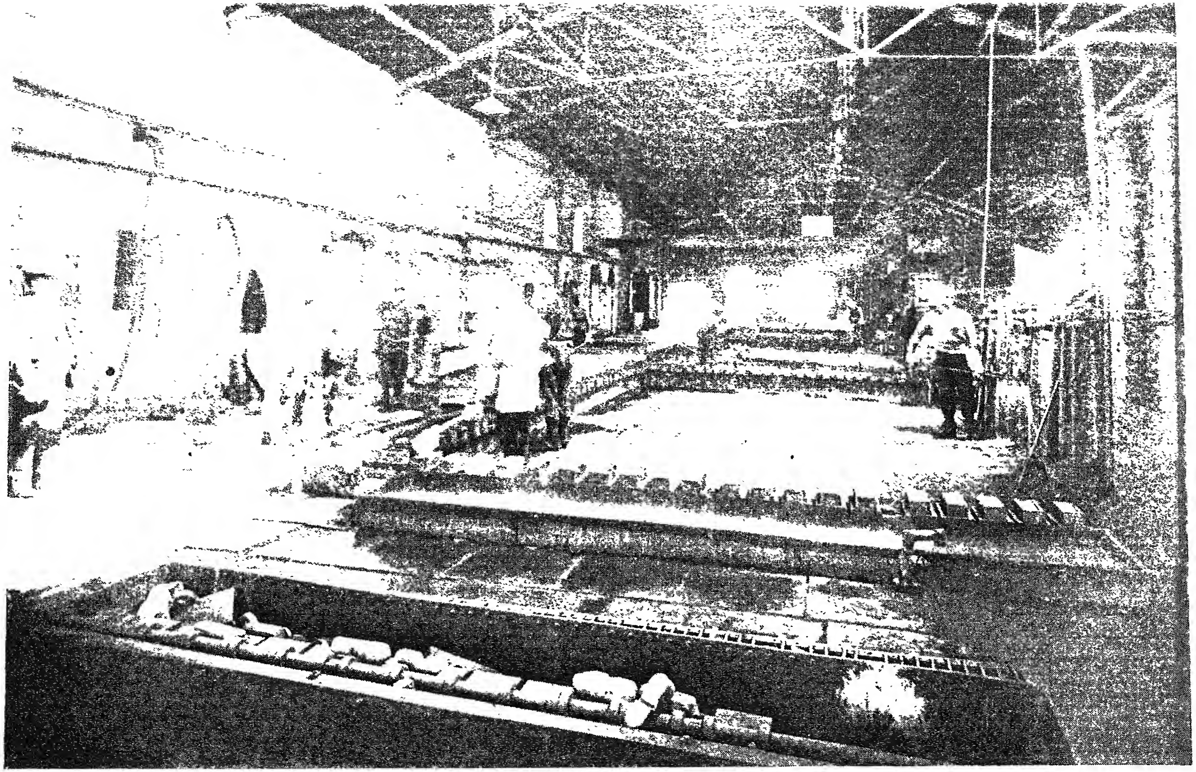
electrolytic method is generally used when it is required to obtain a specially pure copper, as for electrical purposes, rather than for the recovery of the mineral from its ore, a process of electric deposition being employed, the copper being dissolved from the impure slab by the passage of the electric current, to be deposited in a very pure state upon a thin sheet of pure copper. It is a modification of the electro-silver deposition process.

To obtain an impressive idea of the magnitude of the copper industry one should pay a visit to the huge organisation of the Amalgamated Copper Company at Butte, Montana, U.S.A., or to the Mount Lyell property in Tasmania, where a similar picture upon a smaller scale is presented. Curiously enough the Montana field did not arouse attention in the first instance because of its copper wealth. It was gold which lured the prospectors to this district, copper then being of little commercial consequence. It became noised abroad that gold was to be found in plenty under the turf in this corner of the continent. The frenzied treasure-seekers rushed to the territory and madly set to work, hoeing the soil of its virgin sward, only to suffer bitter disappointment. Memories of the days of the wild gold stampede are still preserved in the curious nomenclature, typical of a gold rush, of parts of the so-called auriferous country, such as "Last Chance Gulch." The fever soon died down and the placer miners hied to pastures new, but with very little gold to swell their pockets.

Among those who accompanied the rush was an astute Irishman, Marcus Daly. He probed about and discovered that while there was very little gold there was certainly much copper ore. He also found that the three richest claims had already been appropriated. But he decided to wait a

while; he saw that the gold-maddened miners would depart when they realised that gold did not exist, and that they could never be induced to linger there from a superabundance of copper. He had also been studying the contemporary commercial history of the world somewhat closely, and saw that copper was destined to become a mineral of far-reaching significance. One day the prospector holding the three best copper claims expressed his desire to get "quit of the spot." He was sick of the whole business. He was out for gold, not copper. Daly diplomatically asked if the prospector would sell out his claims? "Would he sell? Certainly, if he could find a man fool enough to buy them." Daly offered himself as the fool and so secured possession, for the proverbial song, of three claims which subsequently became the greatest copper-producing mines in the world, the Anaconda, Neversweat, and St. Lawrence, respectively. The disappointed gold prospector went his way; Daly set to work to open his treasure-house.

That was in 1880, when what is now the town of Butte, with a population exceeding 80,000, was little more than a collection of tents and shacks. The new owner at once set to work burrowing into the hills which he had acquired, tearing out the valuable ore. Galleries were driven in all directions. The three mines are contiguous, forming what is known as the hill of Butte, but the galleries now spread out like tentacles in all directions from the hill which constitutes, as it were, the body of the great mining organisation. So intricate is the network of galleries that the countryside is absolutely honeycombed with the workings, which reach under the streets and houses of the town itself. The mine is vast in the fullest sense of the word. In this ant-hill 10,000 miners find steady and constant employment. Every twenty-



CASTING COPPER INGOTS, IN WHICH FORM THIS VALUABLE METAL IS SOLD

four hours they tear out 15,000 tons of ore and dispatch it to the surface. The wage bill exceeds £8,000 a day. If one were to set out upon a tramp of the underground workings one would need to walk 1,000 miles before one could say that one had explored the whole of the gigantic copper warren.

After he had set the mining enterprise going the Irish owner at once cast around to secure a site for the plant in which to smelt the ore. Copper is absolutely useless unless economic means to work it into the product of commerce be available. But a smelter is a costly installation, and it is not every mine which can afford to lay down such a plant. It is by no means uncommon to see ore sent several hundred miles to the nearest smelter to be treated, and this inflates the cost of production, seeing that transport of the ore involves the conveyance of much useless quartz and earth.

Daly decided to plant his smelter away from Butte itself, which, once the copper-mining industry started, became known as the "Smoky City," and the most uninviting spot for miles around. In smelting copper clouds of blue poisonous fumes are driven off, which spell immediate death to vegetation. In some copper-smelting districts the earth is as gaunt, sterile, and as forbidding as Pompeii. All trees, shrubs and grass have been scorched, shrivelled and killed by the deadly vapour. Daly found an ideal site for his smelter at Anaconda, about a mile from the mine, where there was ample lime-rock to serve as the flux, timber and water. Here he planted the requisite installation in a gulch, and it was brought into operation in 1883. But it speedily proved to be inadequate for the work in hand. The demand for copper began to rise by astonishing leaps and bounds,

and ore was being torn from the heart of Butte Hill in far larger quantities than the smelter could handle.

So the "Copper King," as Daly came to be known, commenced the erection of a larger plant on the top of a hill near by, his intention being to take full advantage of the higher ground to allow the smoke to be belched into the air from a lofty chimney stack at an altitude which would preserve the agricultural land below from its ravages.

Daly did not live to complete his ambitious scheme. His interests were taken over by the giant Copper Corporation which was formed, the price paid being £10,000,000, for what the Copper King, but sixteen years previously, had paid only a few pounds. The new owners proceeded with the smelter, which, when completed, constituted one of the mining wonders of the world. It is the largest and most expensive copper smelting plant which yet has been erected, its total cost being £2,600,000. Its most conspicuous feature is the gigantic stack projecting from the crown of the hill. This is 40 feet in diameter inside at the bottom, tapering to 30 feet at the top, while the huge mouth is 350 feet above the ground. In this manner it was found possible to discharge the poisonous sulphur fumes into the air at a height of over 1,100 feet above the valley below.

This gigantic smelter knows no rest; it is kept going the round 24 hours. Its appetite is enormous. During each round of day and night, to ensure a steady stream of copper pouring from its furnaces, it is fed with 12,000 tons of copper ore, 2,300 tons of limestone drawn from the adjacent quarries, 1,000 tons of coal, 650 tons of coke, and 500,000,000 gallons of water. No sponge ever absorbed larger quantities of water than this plant. Its thirst is amazing, and can only be assuaged with 38,000 gallons a minute. To keep the smelter

and the mines going the whole year round 400,000 tons of coal are required. The narration of these figures serves to convey some idea of the stupendous scale upon which operations are conducted at this copper city. Consequently, it is not surprising to learn that at least 250,000 people are estimated to be dependent upon its activities. If the mines gave out suddenly, and the smelter had to be closed down, widespread ruin would ensue, because Butte, and the country for miles around, live, move, and have their being amid copper.

I have pointed out the widespread damage wrought upon vegetation by the fumes thrown off in copper smelting. Daly and his successors, the Copper Combine, sought to overcome this evil by throwing the fumes from the smelter 1,150 feet into the air to ensure complete diffusion. But the local agricultural interests maintained that they were suffering widespread damage to their crops and cattle from its pernicious sulphurous smoke. They accordingly set out to secure the compulsory abatement of the alleged nuisance and sought reparation in damages. At first the company paid all claims advanced by the farmers, but after spending £100,000 in this way it came to the conclusion that it was being made the victim of a conspiracy. So the company decided to fight the farmers, and the ensuing battle was one of the most bitterly contested actions in the United States law courts. Money was spent like water, by both sides, the first round alone costing over £700,000.

To prove that the so-called "smoke damage," as claimed by the farmers, was fictitious, the company bought a huge ranch and farm to demonstrate that no injury could be caused by the discharge from the chimney. The costs incurred by the Copper organisation were £600,000, but then

it had mines and plant valued at £200,000,000 at stake. Had it been compelled to close the smelter the mines would have had to be abandoned, because the latter would have been useless without the former. In the course of the action the company declared that they had made every effort to conquer the fume or smoke nuisance, but without avail. They had even offered a prize of £200,000 for a successful device wherewith to overcome the evil, and this prize still remains to be won.

The smoke trouble is the *bête noire* of the copper smelting industry. It is not peculiar to the United States, although there are many depressing black stretches of country to be found which have been reduced to sterility and desolation by the sulphur fumes. It affects in varying degree every country where copper-mining is pursued. One needs only to visit the Mount Lyell Mine in Tasmania to realise the significance of this evil. This mine is situated in what was once a vast amphitheatre of forest. But the trees have gone; naught but dismal stumps littering forbidding brown earth which was once covered with luxuriant verdure now greets the eye—and makes one tired. The copper mining and smelting organisations are ever confronted with the menace of organised opposition to their industry; hence their readiness to cure the evil at all costs. A few years ago exception was taken by the residents and farmers in Utah to a smelter placed in their midst. The plant cost £1,600,000 to instal, was equipped with every modern device, and no effort was spared to reduce the magnitude of the smoke menace. But the public triumphed. The company was compelled to abandon its operations.

In the case of a mine such as the Mount Lyell in Tasmania, the damage wrought is possibly of minor

significance, seeing that the industry is planted in a district far removed from the centres of ordinary activity. In fact it is buried in the heart of the mountains. In 1915 the company treated 340,855 tons of copper, producing 7,901 tons of blister copper carrying 7,814 tons of copper, 452,645 ounces of silver, and 9,870 ounces of gold, the total value of the minerals won being £742,312.

As the crow flies the mine is 100 miles from Hobart, but 300 miles by railway, involving two days' journey. The nearest town is Strahan on Macquarie Harbour, 23 miles distant, connection between which and the mines is maintained by the Mount Lyell Railway, one of the most interesting quasi-mountain railways south of the Equator.

The mine itself supports what may be called a typical mining-town, to wit Queenstown. It came into being with the discovery of the copper, lives on copper, and doubtless when, if ever, the mines pass away, it will pass with them. Nobody would live at Queenstown from choice. It is as depressing a spot as one could imagine. Not a leaf or flower is to be seen—nothing but gaunt blackened dead tree stumps littering the brown mountain slopes—all killed by the sulphurous smoke which hangs over the community day and night in a blue, never dispersing cloud. Such is the penalty of industry; but since commerce demands copper, and science so far has proved wanting in the evolution of a cure for the smoke evil, such forbidding surroundings and atmosphere must be tolerated. But the population of Queenstown does not appear to be perturbed by its depressing environment. It flourishes as a well equipped city and is prosperous on the round £1,000 a day distributed in wages among the population, which is composed of miners and their families.

Part of the copper ore is retrieved from a huge open mine

which resembles the vast crater of a volcano. The hole is a big one, some 700 feet in depth, the sides being cut in terraces or benches upon each of which the ore is worked. A round 1,000 men, armed with picks, shovels and drills, as well as numerous other tools peculiar to the craft, swarm these benches, tearing down the ore and useless over-burden, as the top layer of soil is called. There is no dearth of ore. Prospecting has proved the continuation of the stratum to a depth of 300 feet below the present "floor" of the "open cut," representing approximately 3,000,000 tons. The ore recovered from this part of the mine, however, is of decided low grade, though while yielding copper, gives a little more than two ounces of silver, and a few pennyweights of gold, per ton. However, recovery is conducted on such sound lines as to ensure all the metallic contents being recovered.

The ore here varies largely. Now and again richer veins and streaks are encountered. One such strike was a fairly large pocket containing an ore of high grade, which furthermore was rich in silver and gold, as many as 5,000 ounces being recovered from the ton of ore. Altogether minerals valued at nearly a quarter of a million sterling were recovered from this lucky vein. In another corner of this minefield the ore is generally of a grade running up to 6 per cent. The smelting practice is to mix a certain quantity of the low grade with the high grade ore. In this manner some 1,200 tons of ore are passed through the furnaces every twenty-four hours.

In point of equipment the mine compares very favourably with any other in operation to-day. The copper as run from the furnaces, "matte" as it is called, averages about 50 per cent. copper, and this is then subjected to conversion, this process being somewhat similar to that incidental to the

manufacture of steel by the Bessemer process, the impurities for the most part being blown away by blasts of air. In the copper converting process, however, the air blast is not driven through the molten metal as with the Bessemer converter, but at a point above the molten copper. This action sets up various chemical reactions as well as blowing away the bulk of the impurities, leaving a product which, when moulded into ingots, is known as blister copper from the circumstance that it contains a low percentage of impurities. This is dispatched to other points, principally to America, the largest purchaser, for further refining.

As a producer of copper Tasmania is seriously challenged by Queensland. Upon the Cloncurry field, the richest cupriferous area yet discovered upon the Australian continent, copper-mining is being brought into increasing activity. For some time the development of this field has been handicapped by the absence of transportation facilities, especially railway communication. When these are improved it will be possible to carry development work forward at an enhanced pace and upon a more extensive scale. Notwithstanding the difficulties encountered the Cloncurry field has already demonstrated its possibilities, its contribution in 1915 having been 9,880 tons valued at £716,796. The Mount Morgan Mine, in the same State, where the copper is found combined with the gold, was second in the list of contributors to the State's yield during the year in question, with [illegible] tons.

The mine in which the winning of copper is at present being conducted upon the most spectacular scale is at Bingham in the State of Utah, forty miles from Salt Lake City, of Mormon fame. The opening up of this copper deposit constitutes an absorbing romance of grim determina-

tion coupled with imagination. The Oquirrh Mountains are a range of shaggy towering humps intersected by narrow gulches. The ravines are so narrow, indeed, that they present a sharply-shaped V when viewed from a broadside coign of vantage. Bingham is situate in one of these typical ravines, the massive mountains crowding in so closely on both sides as to allow the mining town to possess only one street, which fills the bottom of the V. Streets cannot climb the mountain slopes because they are too precipitous. It is a strange town, the houses jostling one another and stretching for a mile along the feet of the mountains towering high above, following every kink and twist in the canyon.

Bingham has been known as a mountain mining-town for years. It leaped into fame as a corner of the ragged mountain range where lead, gold and silver might be found in abundance. For years intense activity prevailed, but twenty years ago the outlook became ominous. The lodes were becoming more attenuated and it was a matter of speculation as to how much longer they would hold out. Investigations were conducted by the scientific staff attached to one of the affected companies, which found little gold but copper ore on every hand. However, it was of such a low grade—ranging from 1·4 to 2 per cent.—as to be described as totally unworkable. The crisis came in 1900. As anticipated, the metals did not pay to work. The miners, or rather those remaining, for many had gone, commenced to gather their few worldly goods together, ready to make a complete evacuation. The doom of the town appeared to be sealed.

One day a stranger appeared in the town, which had assumed a more than usual fit of the blues. He bustled round making inquiries here, asking questions there, and chatting with some of the oldest miners somewhere else.

With one or two metal winners to act as guides he wandered over the workings, picked up a few pieces of ore, examined them critically and slipped some fragments into his case. Then he went away, vanishing as suddenly as he had appeared.

A few days later he came again and hurried off to the office of the gold company. There was a brief and crisp colloquy. The new arrival told all present what they knew only too well. He explained that the gold, silver and lead were minus quantities, but that there were copper deposits running into millions of tons waiting to be worked. The shareholders and administrative officers smiled. They agreed that there was plenty of copper, but what was the good in working such a low grade? It could never be made to pay. To show a profit a six per cent. ore at least would be required. The stranger was politely requested to take his suggestion for working 2 per cent. ore elsewhere. The interview closed, and the arrangements for closing down were resumed.

However, Bingham could not shake off the stranger. He reappeared. Would the present shareholders, if they were unwilling to support him in working 2 per cent. copper, sell out their holdings? Certainly! So the mine changed hands at a ridiculously low figure, and they chuckled over the transaction, for they thought they had driven an astute bargain. But a change came over Bingham, one which was amazing and startling. The persevering stranger was a well-known mining engineer who had developed his own ideas concerning low-grade copper mining, and was now going to put them to the test, having obtained all the financial support he desired. Miners were invited back to Bingham, and their ranks were swelled by others who, hearing of "big

things doing up Bingham way," trekked to the old mining town. For weeks the railway station nearest the mountain town disgorged nothing but steam shovels, railway locomotives, wagons, steel rails and a bewildering complexity of other machinery, all addressed to Bingham. Within a few weeks the drowsy mining centre, the "was-ser camp" of the Oquirrhs, was a scene of activity without parallel in its history.

To-day the visitor standing upon the railway skirting the mouth of the canyon beholds one of the most stirring spectacles identified with mining enterprise in the world. Far below him straggles the one street town, with its strange twists and turns. Far above him he sees white wreaths of smoke and railway trains so small as to appear like toy creations crawling along huge terraces or benches. From crest to toe the flank of the mountain has been cut into steps, on each of which are toiling huge ponderous steam shovels swinging 5 tons at a time. The mountain is being devoured bodily, is being passed through the smelter in a continuous stream, and is being compelled to relinquish its hold upon the precious copper as it passes through the intense fiery ordeal.

Bingham is the most extraordinary open mine in the world. Within fifteen years it has been lifted from a dying undertaking to the largest single copper producing concern upon the North American continent. It represented the first determined effort upon a grandiose scale to attack ore carrying copper only to the extent of 1·4 to 2 per cent., when copper-mining experts upon the continent maintained it could never pay to touch anything below 6 per cent. It completely disproves old-fashioned theories concerning mining, and conclusively demonstrates that the lowest grade ores can be made

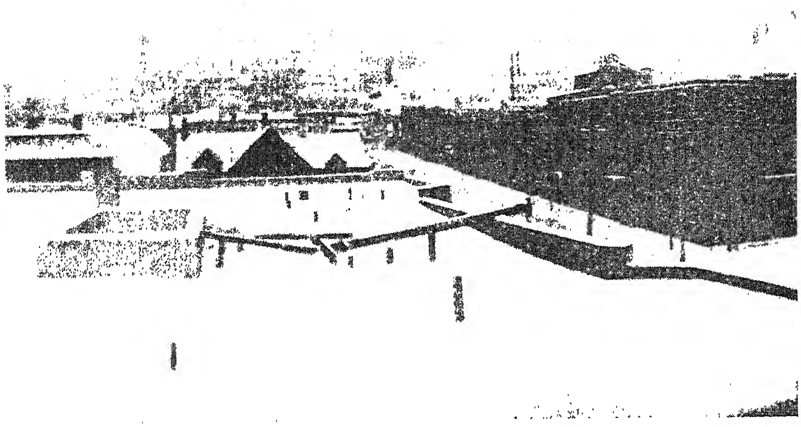
to pay if worked upon a sufficiently big scale. In the course of fifteen years the shareholders in the new venture received £5,000,000 in dividends, while another £5,000,000 was spent in development work and the acquisition of further machinery.

Copper mining is carried out upon a sensationally grandiose scale. To bring Bingham into close touch with the railway systems of the continent, the new mining engineer laid down a mountain railway 20 miles in length, which is regarded as one of the most daring pieces of work of its kind in the country. Upon the huge benches which he cut into the mountain flanks he has laid another 80 miles of standard track, over which rattle to and fro locomotives as big as any seen upon an English railway, hauling steel cars, each of which are charged to the brim by the mighty steam shovels. The whole mountain side, 1,500 feet high from the gulch to the crest, is being attacked simultaneously from twenty-four successive steps. Work is carried out the round twenty-four hours in two shifts. Every morning when the shift changes the blasts are fired, and there is a repetition of the operation in the evening when the day gangs give way to the night workers, six tons of dynamite being fired every twenty-four hours in this manner. In the course of the twenty-four hours explosives tear out, and the railways move, 75,000 tons of spoil, of which 25,000 tons represents ore which is suitable for milling.

The mining engineer's attack upon the mountain to obtain the ore represents only one aspect of the problem. It must be treated to secure its metallic content. It would never pay to load up railway trucks with ore to dispatch them to a distant smelter, seeing that out of every hundred tons of ore only two tons represents copper. It would be an

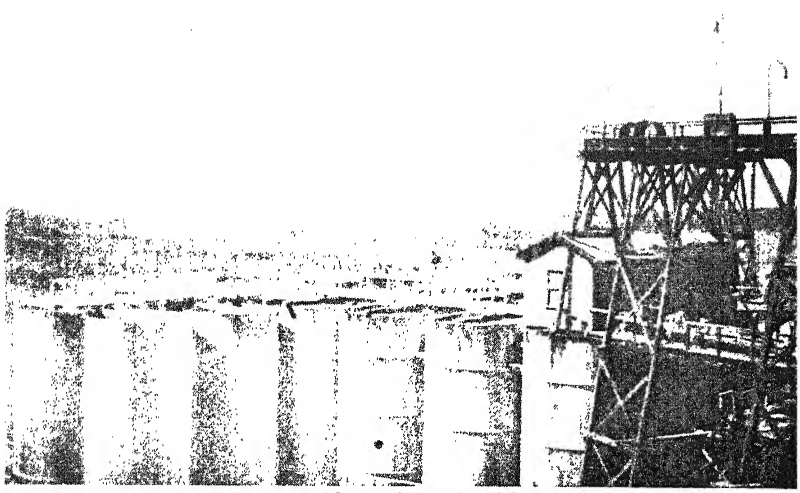
instance of paying freight upon the carriage of useless earth. So search was made for a suitable site in the locality upon which to erect a smelter as well as crushing mills and other plant necessary to the task, not only for the one, but the other copper mines which sprang into existence in the vicinity. It could not be planted at Bingham for lack of space, but at Garfield, 20 miles distant, an ideal spot was found, and here an elaborate plant has been installed. The ore is brought to this plant by railway, while much of the ore is moved over the tops of the mountains and across the yawning gulches by means of aerial ropeways, the cars on which swing to and fro with monotonous regularity, automatically shooting their contents at the desired point. In one instance the approach to the smelter was found to be so awkward as to bring development to a stop. But only for the time being. The engineer could not go round the obstacle, nor could he go over it, so he ploughed clean through it, driving a tunnel two miles long solely and exclusively for the movement of the ore.

In mining, as in all other ventures incidental to commerce, audacity wins. In this instance an amazing success has been achieved. The magnitude of the operations cannot be grasped from the army of toilers engaged in the task, since the work offers employment to only some 3,000 men divided between the two shifts. But the dearth of manual labour is redeemed by the elaborate character of the mechanical plant. The piecemeal removal of the mountain is proceeding at a rare pace, and the mass of rock is being resolved daily into 180 tons of copper, some 2,200 ounces of silver, and over 200 ounces of gold, the value of which may be set down at approximately £16,000. The quantity of rock and waste handled by the steam shovels during the week exceeds



BUTTE MONTANA, WESTERN AMERICA

The biggest and most remarkable copper camp in the world.



Photos.: Permission of the Denny Chemical Engineering Co.

ONE OF THE MOST FAMOUS SILVER MINES IN MEXICO

The agitation tanks at the Pachuca Santa Gertrudis Mine.

1,000,000 tons, and the copper is being won, after making allowance for the value of the other minerals, at a cost of less than sixpence per pound!

The copper field upon which all eyes are riveted at the moment is that which has been discovered in the vicinity of Lake Tanganyika. The continent of Africa has been regarded as Nature's greatest store-house since the early days of civilisation. Evidences of long by-gone mineral working activity are evident in various parts. Certain it is that much of the mineral wealth which constituted so conspicuous a feature of the great dynasties and empires of the past was drawn from this continent. And we need only to reflect that from Africa the world is still drawing the greater part of its gold and virtually the whole of its diamonds to realise its enormous wealth of treasure. As yet the surface of that vast country has resisted the most cursory examination. What wonders it still conceals is merely a matter for speculation.

The discovery of copper created a mild sensation, for the simple reason that the ore was buried in the heart of the continent, and at the time was so remote as to be apparently beyond all hope of recovery. But through the pertinacity and imagination of a British mining engineer, the obstructions which at one time appeared to be insuperable are being overcome. The Lake Tanganyika copper deposits are located in the heart of the continent, and at the time of their discovery were about 2,000 miles from Cape Town and approximately 1,000 miles from the West Coast. To reach them involved a circuitous and dangerous journey via the River Congo, there being no high roads or bush tracks linking the copper treasure trove with the coast.

The first location sufficed to reveal copper in an abund-

ance such as is presented by no other country in the world. But at that time it cost about £82 per ton to freight in machinery, provisions and equipment, and as much to move the ore out. Thereupon Mr. Robert Williams, the imaginative British mining engineer in question, decided upon a bold stroke—the construction of a railway from the west coast of the continent direct to the fields. To emphasise the possibilities of such a railway a more detailed survey of the copper country was carried out and the value of the deposits proved, representing but a fraction of that actually existing, was estimated at £100,000,000. In these circumstances it was a sound commercial proposal to lay 1,000 miles of railway, because the last-named would be certain to pay if it moved nothing else but copper in the one direction, and materials for the mines and the community established thereon in the other, as experience of a similar nature in other parts of the world has proved very conclusively.

This new trans-African railway is under construction and is gradually approaching its destination. Fortunately for the development of the region in question, the Cape-to-Cairo railway was carried to a point which enabled a branch line to be run into the Katanga country, as the copper region is called. While this does not offer the same advantages as will accrue upon the completion of that being built from Lobito Bay, at the same time it enabled development work to be hurried forward, as well as facilitating the shipment of machinery and plant for the erection of a smelter, which is imperative. Development is now proceeding apace, and by the time the copper railway is completed the mines will have been advanced to a sufficient degree to offer the new line immediate traffic. It is generally asserted that once the Central African copper mines get into their stride the

centre of copper production will move from the United States to Africa, the last-named being able to hold the whip-hand in regard to price by virtue of the richness of its ore, and the fact that it will be possible to win the copper at a much lower figure than is possible in America.

Even upon the North American continent new fields are steadily being opened up. North British Columbia and the Yukon territory, as well as Alaska, are in reality one continuous, inexhaustible treasure house, all the essential metals of commerce being found in abundance. But at the moment problems associated with transportation are proving a formidable handicap. In Alaska a decidedly aggressive move has been made by driving a railway from Seeward to the Copper River, so named from the fact that it is lined on either side with vast deposits of this metal. To a certain degree activity is adversely affected by the climate, which is certainly rigorous in these northern altitudes, but as settlement proceeds it is anticipated that the conditions will fail to exercise such an antagonistic influence as is the case at present.

CHAPTER X

The Golden Fleece Which Drives Men Mad

GOLD! What magic there is in that little word. What fortunes it has made—and lost. What a world of fascinating romance, grim reality, tragedy, comedy, pathos, humour and crime is associated with the story of its discovery and recovery. What other prize to be won from the earth is able to stir the emotions so profoundly? What other treasure is able to fire the long dormant instincts and worst passions of the human race so effectively? For what other mineral is man so ready to make tremendous sacrifice, to take such long chances, and to incur risks untold?

To be caught in the swirl of a gold rush is to suffer deprivation of the senses, that is unless one belongs to that strange and privileged hardy race which makes the discovery of mineral wealth the one absorbing object of existence. To aught but these hardy adventurers it is the metal which drives men mad. To raise the word "Gold!" in a backwoods camp is to create a stampede as disastrous as the cry of "Fire!" in a crowded theatre. A camp which to-night is as serene and peaceful as the upper reaches of the Thames on a summer's evening, with the men lolling and smoking contentedly, will be instantly thrown into a state of tumultuous excitement by the receipt of intelligence that gold has been struck a thousand miles away. Distance does not dim the enchantment of the news. One and all will hurriedly pack

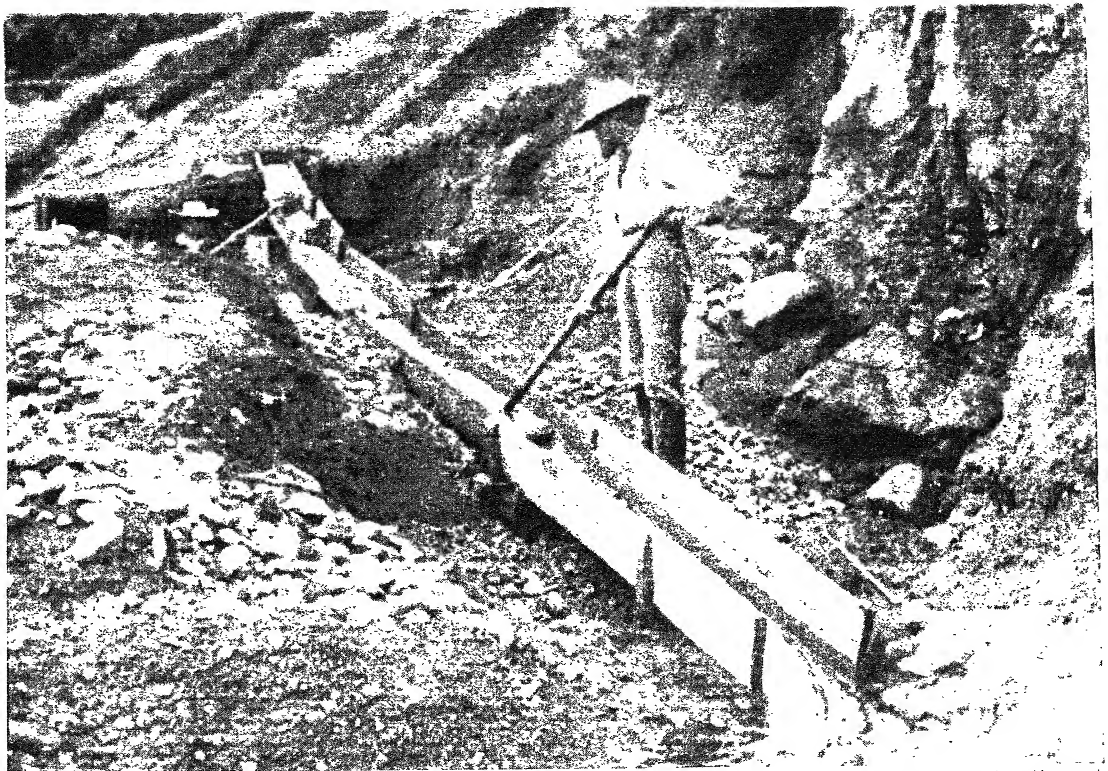


Photo.: Notman & Son, Montreal.

AN EASY WAY OF GETTING GOLD IN BRITISH COLUMBIA

The heavy and valuable gold deposit sinks to the bottom of the "flume" or trough, while the running stream of water carries off the useless materials.

their tents, saddle their horses, or whatever other means of transit may be available, and speed away with frenzied haste. The brain appears to become helpless to do aught but conjure up visions of wealth untold.

I was at one railway building camp in the Canadian North-west. It was during the time of the Stewart gold rush, but this camp had survived the assault which that discovery had provoked. Exactly how defies explanation, but by some means or other word flashed through this little community one evening that gold had been found at Atlin, somewhere Klondykewards; no one appeared to know the precise location at that time. Twelve hours later that camp could show only a ragged remnant of its former population. Scarcely a dozen out of a hundred men remained. They had risen with the dawn to stampede madly towards the new lodestone, lured onwards by the prospect of being among the first to reach the spot. They did not pause to ascertain whether the news was true; delay would react against their chances of making a big strike.

Every announcement of the discovery of gold can tell a similar story. If a practical joker suddenly flashed the intelligence round the world that a big strike had been made at the North Pole, a stream of humanity would immediately set out upon the journey to that inaccessible region, never pausing to think that they were the victims of cruel jest. A few years ago, by some means or other, news of the discovery of the precious metal at a point far within the Polar circle was circulated, and a crazy expedition at once set out to exploit it. When it was noised abroad that gold had been found in California—in those days news travelled slowly, but the intelligence concerning gold flew round the world with amazing speed—the whole earth was flung into

turmoil. The London tradesman closed his shop, the Paris clerk flung down his pen, the sailor abandoned his ship, the Australian farmer forsook his flocks—in fact, men in every walk and station of life in all corners of the world ceased the task upon which they were engaged at the moment, packed their bags and tore off in mad haste to the wonderful golden coast of the Pacific. How they might be able to get there never troubled one of them for a moment. It was sufficient to know that California was bursting with gold, that it could be picked up by the slightest effort. Some made the journey by slow sailing-ship, fuming at adverse weather round storm-tossed Cape Horn; others disembarked at Panama and trudged the narrow neck of miasma forest and swamp to the waters of the Pacific, to take whatever type of sea-going craft happened to be northward bound. Many landed at New York, pushed on by rail to the Mississippi to make the last 2,000 miles across plains, desert and towering mountains by pack-horse, prairie schooner, or even Shanks' pony, incurring hardships, perils, even the hostility of the Indians, such as would be difficult to parallel.

It was the same when gold was found in Australia, South Africa, the Klondyke, and more recently in Ontario, and it will be repeated with every successive strike until the crack of doom, or gold ceases to become regarded as the premier metal for the conduct of commerce. No effective palliative or cure for this virulent fever has yet been discovered, other than hard knocks and mortifying failure. Education is no panacea or preventive; lack of mining or geological knowledge does not constitute an insuperable obstacle. The former is apt to be misleading, while the last-named essentials may be acquired in the stern school of experience. Even the repetition of the never-ending narration of failure and

shattered hopes, handed down from successive rushes, and which to-day in the cumulative degree are staggering, fails to act as an effective deterrent. The chance to make good, although as slender as a spider's web, in a few seconds with a lucky discovery is too hypnotic to be resisted.

Of all the stampedes which have been recorded in connection with gold, none can compare with that which followed the momentous discovery made by Skookum Jim and Charlie Dawson in the Yukon. None can present a similarly terrible tale of hardship, disaster, crime and lawlessness on the one hand, or of extraordinary luck on the other. It is doubtful whether a more forbidding portal to the cave of Nature's treasure trove could possibly have been found. Situate at the top of the world, in a country which had been only perfunctorily mapped, where King Winter holds the country in the palm of his hand for seven months out of the twelve, where the rivers run wild and the mountains are a tangled mass, where the forests are dense and the bogs deep and treacherous, where the mercury in the thermometer plays a ceaseless game of hide-and-seek the round twenty-four hours, except during winter, when it hibernates in its bulb, such was the country which the Indian half-breed and his companion introduced to the world to precipitate a rush in comparison with which the stampede to California and Coolgardie were only Cook's tours.

Here Nature probably put up the stiffest resistance she has ever offered to the winning of her gold. She arrayed all her defensive forces in staggering strength. In the summer it was muskeg—swamp—and windfall which reduced movement to a crab's crawl. This first line overcome, there was the precipitous mountain range, where it was scarcely possible to tread down a narrow trail, and to zigzag along

which was to invite instant death. Even the open waters of the big lakes were deceptive, the river by which they are linked into a chain bristling with snags, rapids, treacherous sand-bars and whirlpools. In the winter the going was easier, but then there was combat against the snow, the intense cold, the avalanche, the mountain wind, and the trail so steep that it leaned back. Those who were fresh from the towns, cities and farms in more congenial climes, and who were woefully ignorant of the rigours of polar travel, juggled with injury and death in a hundred different forms. Many fell by the wayside—seventy-six were swept into eternity by a single snowslide—while many never got any nearer the goldfield than Skaguay, the port at which they disembarked.

Lawlessness and crime were rampant. It was a territory where the human vultures were able to prey unmolested for a prolonged period upon the tenderfeet, as the new-comers were called. These scourges of the human race endeavoured to carry their tactics into the Yukon, but were thwarted at the frontier by British organisation, law and order, in the form of that stalwart protective force, the North-West Mounted Police, who established their outpost upon the windswept summit of the lofty mountain pass where the two frontiers meet. They ruled with a hand of steel, not to prevent the legitimate unlocking of the treasure house, but to protect the ignorant and helpless treasure seekers against a far more relentless enemy—the human parasites who always haunt a gold camp to prey upon the unsophisticated rather than labour themselves. Every gold seeker arriving at this outpost was closely scrutinised and questioned as to his resources in provisions. If he had not at least one thousand pounds' weight of food of all kinds, except tea and coffee,

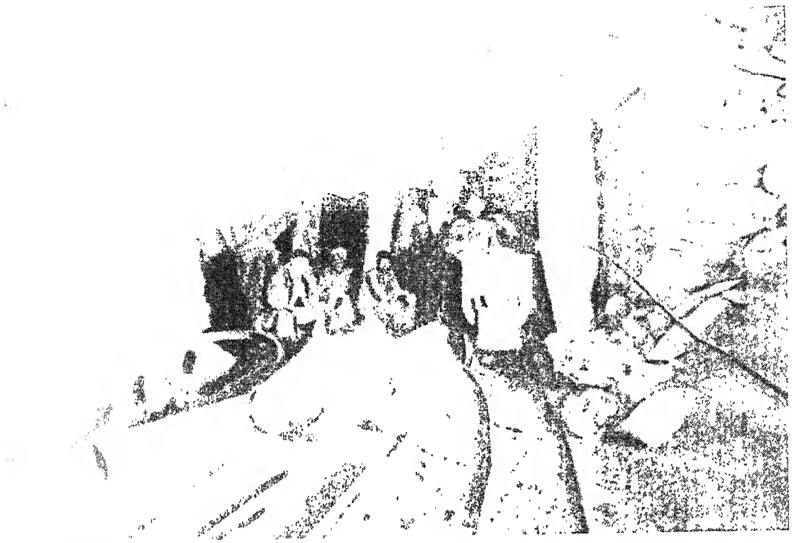
he was turned back. If the record was not clean, or one had been guilty of daubtful practices in Skaguay—the police appeared to be uncannily efficient in gleaning intelligence—one was sternly told that the Yukon preferred one's room to one's company. During the very early days the reputation of Skaguay was the blackest in the whole annals of gold mining. The United States authorities were unable to establish their forces of law and order in the rush. A gang of desperadoes, the Soapy Smith gang, held sway, plundering one and all, until at last an infuriated, long-suffering body of citizens took the matter in hand, shot the ringleader, rounded up the others, and kept them under control until they could hand them over to the American authorities.

In the gold camp itself prices soared to an amazing level. Gold dust was more plentiful than sawdust for a time. A friend of mine who got in on the ground floor, as being among the first to arrive is picturesquely called, paid £3 for the hire of a horse for an hour. A husky, the native dog, which cannot be excelled as a beast of burden in winter, was worth £50. A first-class dog train commanded anything from £800 upwards. Flour at one time soared to over 4s. a pound. Another friend of mine, who, finding his luck out at mining, started business as a baker, paid £30 for 100 lbs. of this commodity. A single potato fetched 2s. A doubtful concoction called beer, made from native materials, found [illegible] in plenty at 4s. a teacupful. The latest newspaper, which down on the coast sold for 1s., found eager bidders at 12s. Gold dust was the medium of exchange, and in many places it was weighed out with a sugar scoop and an ordinary pair of scales.

The roaring days of the Klondyke would fill a book. It is a story without parallel, revealing humanity in its worst

and best forms. But the wild and woolly reign was brief. Hard on the tracks of the stampeders came the forces of science and commerce. They were less impetuous. To them the goldfields were useless until means of conveying the mineral to the coast cheaply were introduced. So a railway was quickly plotted and built, and it is one of the railway wonders of the world. Directly it was opened to traffic a wonderful change was recorded. Prices in the gold camp at once sank to a tolerable level. The profiteers were worsted. There was a violent upheaval, the forces of commerce standing to one side and viewing the spectacle unconcernedly, confident in the knowledge that when the battle had been fought to its conclusion they would be able to step in and secure unfettered control of the field. As they anticipated so it proved. The cream of the goldfield was quickly skimmed. It became more expensive to dig down for the precious yellow metal. Many of the claims showed signs of petering out, as exhaustion is quaintly termed by the mining fraternity. The holders sold out, many for whatever prices they could obtain, and departed for other fields, or to rest contentedly at home with the wealth they had won. In this way the Klondyke settled down to a well-ordered, scientifically exploited goldfield, and this is its condition to-day, although it still contains far more gold than has ever been taken out of it.

So much for the romance associated with the rush to pick up gold. Exigencies of space preclude this side of the story being related in the detail it deserves. but sufficient has been narrated to show the extraordinary grip which this mineral has secured upon the race. The reason why the pursuit of this mineral should be carried out so frantically is not far to seek. In the first place gold is the world-wide



A [illegible] at the [illegible]-feet level in the Crown mines, showing tramway and timbering.

Photos.: High Commissioner for Union of South Africa

Drilling the hard gold-bearing quartz 2,000 feet below surface.

WINNING GOLD FROM THE WONDERFUL RAND REEF

accepted standard of currency. It is invaluable to the arts and crafts. It enters into a long range of industrial processes, and is even of some moment in the production of explosives. From the mining point of view it is the easiest mineral for which to search. It can scarcely be mistaken. It is found in its native form, and, being pure, becomes invested with a currency value the moment it is taken from the earth. It is more readily negotiable than any other treasure, and the market remains steady, gold being subject to less fluctuation than any other mineral.

It may appear to sound somewhat strange, yet it is nevertheless a fact, but gold is probably the most widely distributed mineral. It is to be found in every part of the world, more or less, and geological knowledge, while valuable to a certain degree, cannot say explicitly whether it will be found here, there, or somewhere else. It appears to be cosmopolitan in its fancies. It is just as likely to be found in chalk as in granite. Some countries are deficient in supplies of coal, others are unable to point to any known reserves of iron, but there are very few which can say definitely that they do not contain gold.

As a mineral it has probably provoked more discussion in scientific circles than any other treasure of Nature. Knowledge is not yet able to declare decisively how it is formed and why it should be found in such and such a place. One school maintains that it is due to igneous influences, that it was reduced to the solid state by enormous pressure set up by volcanic energy. The other school declares that it is of aqueous origin, that it was carried in solution, and in this way percolated the earth to occupy all available interstices, crooks and crevices, and was formed as the result of the evaporation of the water. In support of this theory this

school points out the possibility of obtaining gold from sea water. It is a fact that salt water carries an appreciable quantity of gold, efforts to reclaim which have been made at frequent intervals; but scientific knowledge has not yet advanced to the stage permitting such recovery to be conducted profitably. The moment this is achieved gold as a metal will probably depreciate markedly in value. Science is wrestling with this problem, and it is quite possible that a cheap process of achieving the desired end may be perfected within the near future. This is an argument upon which one must preserve the most open mind, so startling are the achievements of contemporary science and chemistry.

At the present moment, however, the recovery of gold is conducted along three broadly defined lines. These are respectively washing alluvial deposits, placer mining—another form of alluvial working—and mining as applied to the excavation of auriferous ore from underground workings. All three methods are widely practised, both upon primitive and highly organised scientific lines.

So far as the alluvial gold is concerned, there does not appear to be much divergence of opinion as to how this came to be associated with the mud and friable earth of rivers, either in the bed, bank or delta. The metal is found for the most part in such circumstances in the form of a finely divided powder or dust, and everything points to the fact that this is the result of the eroding forces of Nature in one or another form—possibly a combination of many such influences. In these cases it is generally admitted that the gold was originally in a reef, locked in the heart of a mountain, or held prisoner by the rock. Then came one of those mighty shivers which this earth periodically makes. The mountains were split and the gold reef laid bare. Possibly

in the process the vein was elevated or depressed. Then a river, either of flowing water or ice in the character of a glacier, was born.

Taking the last-named first, it is easy to follow the subsequent trend of events. We all know now that glaciers, despite their apparent immobility, are persistently moving, though the pace is so slow as to be imperceptible to the eye. In moving over the exposed reef the huge cliff of ice, weighing many millions of tons, exerts a grinding action, and reproduces, upon a gigantic scale, the effect of rubbing sandpaper over a piece of wood, or a sheet of emery cloth over a bar of metal. Particles of gold and rock are ground away, to be carried along with the ice until the latter either tumbles into a river or lake or gives birth to a waterway. The tiny fragments of gold are borne along with the water, and continue their flight until, upon reaching a point where the pace slows down, they are able to sink to the bottom. There it settles in the silt, or may even be cast to one side to be deposited upon the submerged part of a bank. If the velocity of the water is sufficient the particles of mineral may even be carried down to the estuary, to be dropped upon a bar or even the sea bed.

When the reef is exposed to the action of a waterway and the water rushes along tumultuously, a similar effect takes place. The rock is gradually eaten away, to be borne to a distant point to suffer deposition through gravitation. Wind, rain, snow and frost exercise a similar effect, and these alone are capable of bringing down thousands of tons of materials in the form of detritus. In many parts of the world this finely ground up spoil from the mountain flanks is sedulously washed for its yellow metal content.

The process is exceedingly slow. However, we know

that in all her milling operations Nature never hurries; but she completes her work to a fine degree. It is probable that the gold which is being recovered to-day was worn away from the rock in which it had been tightly imprisoned thousands of centuries before this earth could be tenanted by man. It is equally probable that after the present alluvial deposition had been made the earth gave another shiver, turning the reef over once more and inwards, thus shutting it off from external eroding influences. In some cases this shiver was sufficiently severe to lift the alluvium deposits which had been made to heights ranging up to several thousand feet, because some of the placer deposits, which are really very ancient alluvial deposits, are to-day found at high altitudes and virtually demand recourse to mining operations properly so called to withdraw the gold.

It is owing to these caprices of Nature that gold to-day is found in so many strange and out-of-the-way places. It is freely found in Britain, both in the reef and alluvial form, the last-named particularly in Scotland, where several nuggets have been found. One of the richest gold-bearing districts of Britain is Wales, and some of the samples which have been examined have been found to be extremely rich in this mineral. But for the most part the gold is generally associated with other substances and in such small quantities as to be unprofitable to work, although a certain amount is recovered in the form of a by-product. It is quite possible, however, seeing that the occurrence of gold is so irregular, that this country possesses attractive deposits if only they could be found. So far as Britain is concerned, gold is something like oil—an *x* quantity.

But although gold is found in a variety of places and in the least expected corners, the happy hunting-ground of the

in the hope of discovering the most favourable site for the continuation of his work upon broader lines.

The apparatus which generally follows the pan, especially in a totally new district, is the rocker. This is a crude wooden contrivance comprising a box so mounted as to have a see-saw motion, hence the name. The sand is dumped in and the water added, the box being rocked meanwhile, the loose detritus having free escape, while fresh water is steadily added and fresh charges of earth dumped in at intervals. The fact that the gold is some seven times heavier than the earth with which it is associated ensures the metal being recovered for the most part, because directly it is released it drops to the bottom, although if the gold be exceptionally finely divided and consequently somewhat feathery, it is likely to be caught up by and carried away with the agitated water.

As a rule an alluvium deposit is short-lived. Accordingly, although it is worked for what profit it may give, the prospector accepts the situation where he recovers the dust in this manner as the starting-point for further investigations. He knows that the metal has been worn away from the rock, and so he strives to discover the reef. But this is an extremely elusive and speculative quest. There is nothing to guide him as to the day when the gold was dropped at the point where he has trapped it. Similarly he cannot tell whether the dust was brought down by the waterway in which he is working, or really belongs to an extinct waterway, signs of which may have disappeared, except in so far as general indications are concerned.

Development of the field witnesses the introduction of the sluicing system. This involves the building of a wooden trench or conduit, the disposition of which is such as to

allow a flow of water to be maintained through it. In this way work is resolved into shovelling the alluvium into the trench. It is immediately broken up by the water, and the gold, being heavier, sinks to the bottom. It is quite possible, however, that the gold may be given volition by the running water, and to frustrate its being carried away in this manner obstructions are set at intervals which have the effect of keeping the gold from being carried away by the current. A natural head of water is given whenever possible, and one which can be completely controlled; but this is not always feasible. Then the water either has to be baled into the trough or a pump pressed into service. In this case the work of course is more exacting, while the output is naturally reduced, because it is not possible to maintain an even feed either of water or soil, unless more than one be working the claim together. Sluicing is the inevitable result of proving a field, and was the practice adopted in the Klondyke and other alluvial deposits. But there is a great objection to the method because the spoil or tailings are generally heavily impregnated with gold which has defied arrest during its passage through the primitive sluice box. The result is that to-day erstwhile fields such as the Cariboo, the discovery of which created a sensation, but which, so the miners said, "petered out," are being reworked under modern conditions. Even the spoil or tailings from the sluice boxes is again being passed through the recovery process to yield eminently satisfactory results.

As an intimation of the strange places where gold is found one interesting and romantic story may be related, inasmuch as it led to the opening up of a new field. A party of prospectors found themselves stormbound at an extremely isolated part of the Alaskan coast. It was a dreary spot in

the far north and quite off the beaten track, such as it was, of passing traffic. The Klondyke boom was at its height, and the sensational discovery in such a northern latitude prompted the marooned prospectors to prosecute a search along the Anvil river and Snake creek. A little later one of the party decided to return to the spot, and persuaded two other prospectors to accompany him. They reached the spot in September, 1898, and, as a result of their diligence, alighted upon what proved to be a rich deposit on Anvil Creek. Though the place was so far north the news of the discovery exercised the inevitable effect. The following spring a stampede to this remote corner of Alaska ensued, many turning their attention from the Yukon to the new aspirant to notoriety. Within two or three months the spot which had never known but the passing feet of a few white men and Indians became a crowded jostling camp of 3,000 excited treasure-seekers, and what is now the town of Nome was born. The miners crowded so closely together, claiming every available square foot of ground, as to lead to serious disputes. Accusations of overlapping of properties, quarrels concerning boundaries, attempts at claim-jumping, and other offences against mining traditions and practices became rife. The representatives of the American administration were in an awkward position. They were only a handful—an officer and a few soldiers—and were quite powerless to keep the excited fever-stricken gold-seekers in hand and to smooth out their interminable quarrels.

But the situation which promised to become very ugly settled itself. One day an old prospector and a soldier commenced to probe among the sand upon the beach. It seemed a mad quest. They panned and panned, and to their surprise discovered gold, and in attractive quantities. Instantly the

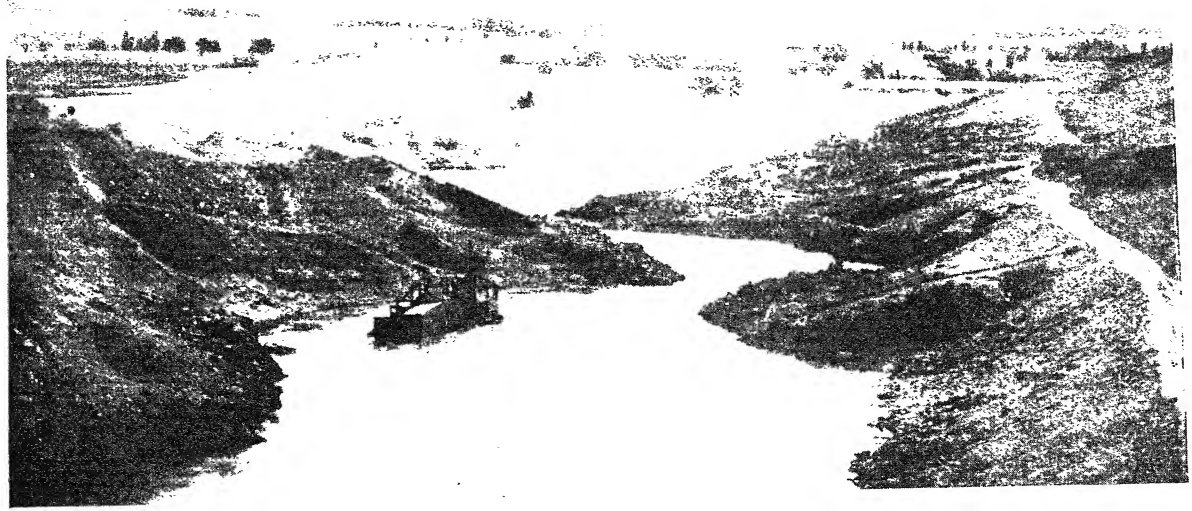
trouble upon Anvil Creek was overcome. No fewer than 2,000 of the 3,000 miners there wrangling and quarrelling at once hied to the beach to stake out claims. Within less than a week a tent city had sprung into existence reaching right down to the water's edge, and the whole of the beach resembled a ploughed field. Sluice troughs extended in all directions, and the round twenty-four hours—there is no night during summer in that latitude—the beach was a scene of extraordinary activity, the miners sticking to their sluice, [illegible] in the beach sand frantically and continuously until [illegible] to abandon work for a few hours from sheer fatigue. Never did a sea-shore yield such wealth. Within two months gold to the value of £200,000 was wrested from the sandy stretch of Nome.

The prospectors, amazed and pleasantly surprised by this discovery, worked from the water's edge inland, and even out to sea. Prospecting was prosecuted diligently yard by yard. In 1901 a second field upon the shore was found, and there was another rush to be in first, because the gold-seeker, no matter how profitable one field may be, does not hesitate to turn to another directly it is proved. By 1908 no fewer than six gold-bearing beaches had been found, and were being worked for all they were worth. And it was sluicing which paid, because in 1908, when sluicing the sandy shore of Nome was in full swing, the beaches yielded no less than £[illegible]. Every ounce was retrieved from the sand.

Consider the situation, then one obtains a fair impression of the lengths to which the gold-seeker will go to gratify his ambitions. The plain at Nome is 25 miles in width. It is washed by the Behring Sea, the loneliest stretch of salt-water upon the surface of the globe. In summer the thermometer hangs around 80 degrees Fahrenheit, which is a pleasant

temperature, but in winter it falls to 18 degrees below zero. By the end of September all streams are frozen, and Jack Frost does not release his grip until the following May. Early in November the same force stretches out to bring the ocean itself within his cold firm grasp, and does not retreat before the advance of the sun until June, so that activity is really confined to about 20 weeks out of the 52 weeks. This suffices to prove how zealously the miners toil, and also the auriferous richness of the sand.

How did the gold get here? This is a question which may well be asked. To seek for gold in the sand of the seashore would seem to offer about as much promise as melting the polar ice or evaporating the salt-water itself. But science has the explanation. The coastal plain is rimmed on the land side by mountains which undoubtedly carry gold. These have been "sand-papered" by weather, rivers and the waves of the sea. The ocean picked up the gold released from its prison of rock, and, after tossing it about for some time, disgorged the mineral upon the seashore, because it is evident that what is now the plain was once covered by the sea. The ocean has been constructive at this point as at our Chesil Beach, and has included the gold in its surrender. This theory is supported by the fact that the respective beaches are not strung along the shore by the water's edge as might be supposed but are ranged one behind the other to the base of the mountains, so that the innermost beach, where gold has been found, is really that which was first formed. This beach building-up process is being continued because, out at sea, there has been discovered another beach in process of formation and which is similarly rich in gold. This, however, does not appear likely to be given up by the ocean for centuries to come, but it proves that the



DREDGING A NEW ZEALAND RIVER FOR GOLD

The demand for the yellow metal is so enormous that even river beds are being torn up, and the dust and nodules separated from the silt to contribute to the world's supply.

building up of the golden sand at Nome is likely to be continued for ages, and that without impoverishing its auriferous value, because the beach nearest the water is yielding the finest gold.

Yet the discovery of the mineral at Nome is not so surprising as it might appear. The whole of Alaska and the Yukon territory is really a huge goldfield. Placer deposits are found everywhere. The land truly reeks of the yellow metal. But whereas much is alluvium, a good deal more is placer gold, and to reach the deposits it is necessary to dig down from 30 to 100 feet, the yellow metal having become covered during the flight of ages with a thick blanket of non-auriferous detritus or over-burden. Mining at this depth, however, is no task for the ordinary gold-seeker. The ground is frozen solid the whole year round, rendering it unworkable to the ordinary tools. Far more scientific methods and plant are required. This applies to the northern gold-bearing country generally, including the Klondyke. To-day the sluice-box has given way to huge dredgers which pick up the soil in capacious steady streams, passing it over tables which are doused with streams of water. Even winter and the most stubbornly frozen ground are no obstacles to the mechanical gold-miner. Pipes are sunk into the ground through which steam is circulated, thawing the soil effectively to allow the mechanical devices to secure a bite, and in this way the yellow metal-laden soil is being torn from its frozen couch, defiance being hurled at Jack Frost and all his works.

Placer and alluvial deposits are encountered in many other parts of the world. The former, where the conditions permit, is treated in a drastic manner. The placer gold is again being eroded by the irresistible force of water, but

water which is harnessed and which is forced to fulfil its duty in far less time than contents leisurely Mother Nature. The monitor is played upon the faces of the cliffs, bringing down the earth in streams. These are deflected into sluices which have been laid down, and with water as the separator, passed through highly efficient recovery plant. The spoil or tailings emerging from the opposite end carry very little, if any, gold.

A rush, which recalls the strenuous and exciting times experienced in the great Canadian North-west, was that which attended the opening of the Coolgardie mines in Western Australia. It may be mentioned, in passing, that the British Empire is producer-in-chief of gold to the world, notwithstanding the resources of the United States. In fact, considered as a goldfield Australia is probably far more attractive than the United States. It was in 1851 that Hargraves sent a tremor round the globe by the announcement of his discovery of a mass of gold weighing no less than 106 pounds, or 1,272 ounces, at the point which now bears his name in the State of New South Wales. Up to this time Australia had been regarded by Europe as little other than a convict colony, but this surprise conclusively testified that "down under" was a corner of the Empire which was destined to play a prominent part in Imperial economics and industry as events have completely substantiated.

Hargraves' discovery was of more significance than the first bald announcement indicated. The piece of pure metal thus picked up, while euphemistically described as a nugget, in reality proved to be the fragment of a reef. Consequently, systematic search for the yellow metal commenced throughout the continent, and the fact that gold might be found induced prospectors to drive their way farther and farther into the

interior, and to laugh at the forbidding nature of their adventures. The gold prospectors have done as much as, if not more than, anyone else to tear the veil of mystery and the unknown from the great Australian continent. As a result of well-organised effort, conducted along adventurous lines perhaps, gold was found in Victoria, South Australia, Queensland, New Zealand and Western Australia, and each find served to impart a decisive forward boost to the State in which it was made, the last big rush being that associated with the West Australian goldfields. This involved the [illegible] of the desert, and the scenes and incidents were strikingly reminiscent of the rush to California. In 1851 the gold contribution of Australia to the world's requirements, and which were drawn wholly from the two States, New South Wales and Victoria, totalled £1,319,932. In 1915 they reached £8,270,339. During the sixty-four years —1851-1915—the Australian continent furnished gold worth no less than £572,433,770, which serves to bring home the enormous value of this corner of the Empire, the gold reserves of which as yet have been barely scratched. High-water mark in regard to output was attained in 1903, when the continent yielded gold valued at £16,294,684, to which volume Western Australia contributed slightly more than one-half, namely, £8,770,719, the highest figure yet reached within that State.

The Western Australian goldfields only came into existence in 1886, and their debut as a gold-producing State was exceedingly modest, the year's output only being worth £148. Ten years later it had jumped to over a million sterling. During the next two years the output increased by no less than 500 per cent., and within thirty years it furnished gold valued at £125,258,153. The gold-bearing area covers

more than 330,107 square miles, a tract large enough to receive Great Britain and Ireland nearly three times over. But the most amazing feature of this goldfield is that it contains probably the richest square mile yet found on the surface of this earth.

The development of this field was handicapped by the serious shortage of water. It not only hindered the actual expansion of the industry, but rendered the field precarious to the lives of the workers and others who established themselves in this inhospitable corner of the country. The gold for the most part is extracted from a dreary scorching desert. While the yellow metal is undoubtedly in abundance, natural water is extremely scarce. The Government decided to repair the remissness of Nature and to send water in a steady stream along an artificial conduit to the sterile territory. Accordingly, in 1896 one of the largest engineering enterprises ever consummated upon the continent was taken in hand. On the Helena River, 18 miles from Perth, a gigantic wall or barrage, 775 feet in length was erected to a height of 100 feet above the river bed. At the base this wall is 85 feet wide and tapers to 11 feet at the top. Behind this the water is impounded, forming a gigantic reservoir, known as the Mundaring Weir, which, when full, extends up the valley for a distance of seven miles, representing a total supply of 4,650,000,000 gallons, which is adequate to supply 500,000,000 gallons a day to the goldfields and the towns en route. But the provision of the reservoir represented only one feature of the scheme. The goldfields are 351½ miles away, and the water is delivered through huge steel pipes, 30 inches in diameter, by means of pumps, eight stations to lift the water over this huge gap being provided. The undertakings in question, known as the "Goldfields Water Supply," supplies

all water required for drinking purposes over an area of 16,000 square miles, and was carried out at a cost of £3,388,901. It was completed in 1903, in which year the goldfields and people residing at Kalgoorlie, numbering about 30,000, commenced to draw pure, fresh, and cool water, caught in the Darling ranges from the household taps. To make sure that the community should never be confronted with a water famine through failure in the supply, subsidiary tanks, dams and reservoirs have been laid down for storage purposes, including conservation of the surface water, the total capacity of which is over 200,000,000 gallons. Consequently, to-day, the risk of water shortage no longer assails the mines upon the Golden Square Mile and other parts of the State.

So far as Australia is concerned all methods of gold recovery are practised—alluvium, placer-working and mining respectively. Powerful dredgers have been acquired, and these are diligently and systematically dredging the beds of the alluvial rivers for the yellow fleece. Hydraulic sluices are utilised for washing down the gold-bearing banks of alluvium, while deep burrows are driven into the earth to wrest the metal from the reef. Some of the mines are of great depth, notably two in the Bendigo districts reaching down to 4,614 and 4,318 feet respectively, while altogether in this State, Victoria, there are fifty-three shafts exceeding more than 2,000 feet in depth.

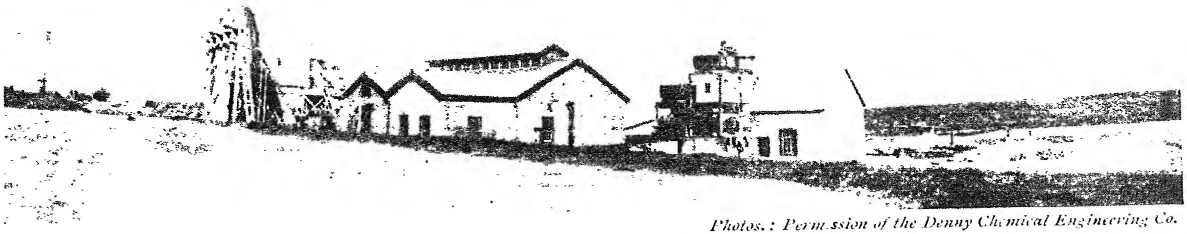
One of the most notable of the Australian mines is the Mount Morgan mine in Queensland, a few miles south of the tropic of Capricorn, and 25 miles to the south-west of Rockhampton. The discovery of this mine furnishes another contribution to the endless romance of gold-mining. In July, 1882, the Morgans were out prospecting for silver on Nine

Mile Creek. The quest was abortive, and they were returning to Rockhampton empty-handed, when the creek being in flood owing to heavy rains, they were driven to shelter in a shepherd's hut on the Dee River to wait the fall of the water to such a level as to permit progress. It was an exasperating delay and time hung heavily. However, to kill the tedium, one of the Morgans decided to go prospecting, being prepared for anything which might turn up. In climbing a hill his attention was arrested by some peculiar boulders. They were veined and the markings looked like iron. He picked up some of the rock, and going down to the creek, crushed it to pan the ground earth. The result was somewhat striking; so much so that he and his companions secured a supply of the rock, which they took back to Rockhampton to be assayed. The scientific report was somewhat astonishing, showing a return of 3,700 ounces of gold to the ton. Needless to say the Morgans, who had kept all information concerning the find to themselves, returned to the hill where the rock had been picked up, carried out further systematic prospecting, and then pegged off as many claims as they were entitled by law to hold. Upon their return to Rockhampton, having secured their property, they formed a small syndicate to work the prospects.

In 1886 the development work had been carried to such a point as to permit the conversion of the syndicate into a public limited liability company of £1,000,000 capital. The Morgans sold out their interests to the syndicate for a round £62,000, so did not participate in the subsequent remarkable prosperity of the company. Nevertheless, it is few prospectors who are able to point to such a big reward for a prospect, but in this case it was fully worth the sum paid. The ground upon which the mine was located formed part of

Meyer and Charlton Gold Mine mill, tailings plant, [illegible] compound and hospital.

View of conveyed belt-system for handling ore from the shafts to the crushing mill (New Goch Mine Johannesburg)



Photos.: Permission of the Denny Chemical Engineering Co.

Tailings wheel (Van Ryn) which lifts crushed gold rocks to the cyanide and slime plants.

GOLD MINING IN SOUTH AFRICA

a stretch of grazing land belonging to a Scotsman, and the mineral area desired was bought for £1 per acre, a mere bagatelle according to subsequent developments. Altogether 750 acres were rounded up for the mine, and, as results have proved, this practically represents the whole of the mineral-bearing land in the locality. Although the success of the Morgans prompted a mild rush to the spot, and frequent prospects have been made in the vicinity since, never a further trace of gold has been found.

For years the mine was only worked for its yellow mineral, but, in 1903, while drilling from the lower levels an unsuspected bed of copper was discovered. Assay revealed that this ore averaged a little over 3 per cent., as well as 5 pennyweights of gold per ton, while survey showed that the strata carried nearly 3,000,000 tons of the ore. Accordingly it was decided to drive down to this big deposit, and to establish plant for working both the copper and the gold. Henceforth the treasure, which had been worked for its gold, became a gold and copper mine. During the first eighteen months' full working in the dual capacity it extracted gold and copper valued at £13,015,370 gross, and distributed over £[illegible] in dividends, which serves to convey some idea, not only of the huge scale upon which operations are conducted, but the immense wealth lying below the surface of the Australian continent.

In contrast to the comparatively big reward which the Mount Morgan prospects secured, and the sustained progressive [illegible] of the mine, is the fickle history or vicissitudes of the Camp Bird mine, one of the most famous in the State of Colorado. In 1876 an American, Weston, acting as London representative for an American company received a letter from a British friend in Denver urging him to enter the

weights per ton of ore. Mining for gold may sound attractive and bestir the imagination, but in reality it is one of the most dismal forms of mining practised. In the first place, as upon the Rand, one has to dig deeply down to encounter the peculiarly distinctive banket. When first opened the reef was attractively productive at a depth of 2,000 feet, but the world's cry for gold was so insistent and insatiable as to demand the rapid increase of effort. When a round seventy mines, all splendidly equipped with the latest devices evolved by highly organised science and engineering, set to work in grim earnest upon that reef, it tore the banket out at an amazing speed. Gold streaks like coal seams do not last for ever, and so, as the upper levels became exhausted, the shafts had to be sunk to greater depths. It is the pace which is telling, and it is even declared that, if the present rate of production be maintained, some of the mines will have to be abandoned, through petering out of the gold, within about twenty years.

So say the pessimists, but there are so many surprises locked up in the heart of the earth as to render any such assertions purely speculative and idle. True gold is an uncertain quantity, and the enterprise is perhaps somewhat more uncertain when effort is confined to the reclamation of the one mineral. But the Rand mines have already been carried down to 4,000 feet touching superincumbent layer after layer, and it is stated that they may even have to be continued down to the 7,000 feet level. Should this prove to be the case the gold mines will easily rank as the deepest in the world. Working at that depth will be attended with trials innumerable, costs will be increased, while grave difficulties will be encountered in regard to ventilation. At the 3,000 feet level the temperature is 77½ degrees Fahren-

heit; at 5,000 feet it will rise to 84 degrees; and to 95 degrees when the 7,000 feet level is reached. Toiling in such an oven will impose a severe strain upon the miners. It will be difficult for them to maintain output since work will be so exhausting. But possibly by the time it becomes necessary to tear out gold from more than a mile below the surface of the earth, ventilating science will have made great headway, rendering the efficient circulation of pure, cool and invigorating air through galleries at 7,000 feet as simple and effective as it is to-day at a depth of 500 feet.

A gold mine is a wonderful underground factory, and it affords employment for a diversity of trades. The machine rooms, nearly a mile down, compare with any to be found on the surface. Huge chambers have been hewn out of the solid rock to receive mechanical appliances of every conceivable character, from blacksmiths' forges for sharpening the drills to pumps and lighting plants, while railway workers are housed to lay tracks, electricians to string new lighting and power circuits as well as to attend to motors and other plant. The carpenter even is in keen demand, fashioning woodwork of all sorts and descriptions to meet local needs at the bottom of the shaft.

The ore is run up to the surface in skips at amazing velocity. Reaching the daylight the carriers are automatically emptied of their contents to disappear as quickly down the black hole. From the dump the ore is passed to the battery house where it is passed through ponderous stamps, dozens of which are set out in long rows, and which fly up and down without ceasing the round twenty-four hours. Each stamp weighs three-quarters of a ton, and its duty is to crush the ore as it passes beneath in a steady constant stream to powder. It is the familiar pestle and mortar of the domestic

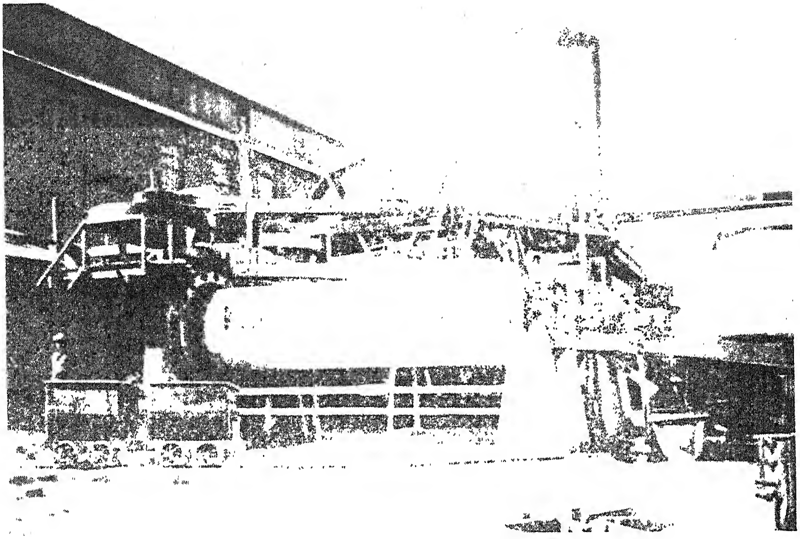
kitchen working upon a gigantic scale, and the din is deafening. It is not a clump, or a screech, but an ear-drum-breaking roar, which continues without intermission night and day. Mining for gold knows no cessation. Drill, dynamite, brawn and muscle, and stamps toil unceasingly, such rests as are made only being due to the necessity to perform some overhaul, or to effect a repair.

Such powerful pounding powders the rock, and combining with streams of water the powder is converted into a slime. This runs through a sieve, and then at a slow pace passes over an inclined table. Here the recovery of the gold commences in grim earnest, and it is an interesting process with chemistry as the wizard. The tables are of copper and treated with mercury. Now quicksilver has an irresistible fancy for gold, and, so as the tiny invisible yellow particles pass, they are seized by the mercury and held tightly, forming an amalgam. But although the mercury is alert and its grip unrelenting it cannot arrest all the gold during the passage. About forty per cent. eludes the quicksilver and passes away as tailings. The amalgam itself is scraped from the surface of the table and thrust into a retort. Here, under the action of heat, the mercury is compelled to release its grip of the gold. The quicksilver is converted into vapour and passes away to be condensed and to fulfil a further spell as policeman, empowered to arrest all yellow metal. The gold released from the embrace of its companion is recovered in a spongy mass, is melted down, and then run into moulds to cool into solid cakes or bars, each of which is worth £3,000.

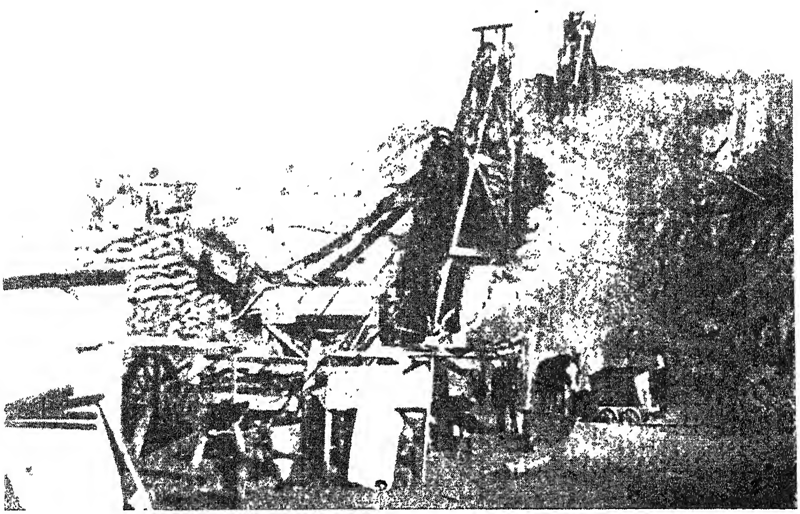
Formerly the 40 per cent. of gold which eluded the mercury during its travel over the tables was lost. The tailings were led away and discharged upon the waste heap.

Huge hills of pulverised banket have been formed around the mines. These dumps constitute a prominent feature of the Rand and are visible for miles around. How much gold these unsightly hills still retain is a matter for speculation, but it must be considerable, seeing that nearly one-half of the yellow metal contained in the crude banket escaped recovery. But very little gold is able to get away to-day. The loss of that 40 per cent. aroused the interest of the chemist. Could he not find ways and means of wresting the whole, or nearly the whole, of this valuable yellow product from the particles of earth with which it was associated? At all events he set to work to endeavour to achieve the apparently impossible. In due course he evolved a beautiful and simple chemical process, the perfection and proved efficiency of which served to effect a wonderful transformation in the gold industry, not only upon the Rand but throughout the world.

Chemistry is wonderful wizardry and we see it expressed in one of its most charming forms in connection with gold recovery. Around the mouth of the mine are distributed what appear to be huge tanks. They are set out row after row. From the distance, if one did not know it was the Rand, one might think one was approaching an oil-producing centre instead of the busiest gold-producing hive in the world. These vats look just like the tanks which receive the crude and refined products at the oil refinery. Each vat is charged with a solution of cyanide of potassium, and the tailings as they escape from the tables are led to a big wheel which lifts the stream of slime to a height to discharge it into troughs. These conduits extend over the network of vats, and the arrangement is such that the stream may be emptied into any tank as desired.



Tube mill and tailings wheel.



The washing plant.

AT A JOHANNESBURG GOLD MINE

When the tailings drop into the vat there is a sudden changing round. Cyanide is a notoriously fickle friend; its companions are many, but it will abandon one consort the moment another kindred spirit comes along, and without the slightest compunction. As the tailings tumble into the vat the cyanide drops its acquaintance with the potassium and chums up with the gold, the result of the union being a new product—cyanide of gold. But the chemist does not approve of this match except in so far as it suits his purpose. Directly the two have become wedded he leads them away and now sets to work to separate them. In the extractor house are some more tanks. These are charged with zinc shavings, and each tank, it may be remarked parenthetically, is securely locked. The cyanide of gold comes along all unsuspectingly. The solution tumbles through a screen into the tank. The cyanide has scarcely survived its pleasure of union with the gold when it encounters another friend for whom it has a greater attachment. It unceremoniously drops the gold and embraces the zinc. The gold tumbles in yellow particles to the bottom of the tank, completely spurned and rejected, but to the inexpressible delight of the gold-winner and his colleague the chemist. At intervals the tank is unlocked and the yellow deposit removed to be subjected to a smelting process and is finally turned out in bright gleaming bars weighing 70 pounds apiece—pure gold.

The discovery of the flirting properties of cyanide has brought wealth untold to the Rand gold-seekers. The tailings which are now thrown upon the dump can point to very little if any gold. But more than this is to be recorded. The process is so cheap that it is paying to introduce the tailings of years ago, and which carried away nearly half of the gold contained in the original banket, to the quaintly

amorous tendencies of the cyanide. In this way the gold output is not only being increased but the efficiency of the whole mining process raised to a wonderfully high level.

The wealth which has been won from the Rand reef is amazing. In value it exceeds £400,000,000, and as yet there are no signs of the banket becoming exhausted. Despite the Jeremiads the day when the reef will peter out is still far distant. Moreover, although the search for gold is being conducted with greater energy to-day than ever, and in all parts of the world, the Rand has not yet been eclipsed as the world's richest mint.

The call for gold to satisfy the exigencies of rapidly increasing commerce and industry is leading to strange developments, and inducing the gold-winners to resort to the most herculean efforts. Fever-laden rivers are being penetrated with dredgers which are tearing up the silt to pass it through screens and over big tables, the gold being arrested in its bewildering passage. These dredgers, wonderful creations of the engineer and shipbuilder, are to be found in every corner of the world, and are toiling laboriously in many places where signs of other human life are few and far between. They are scraping the river bottoms in the far north and in the heart of the jungle. Neither intense heat nor blood-solidifying cold acts as a deterrent. In the equatorial regions the strange craft is enclosed in an expanse of netting to preserve the workers from the attacks of the pugnacious malaria-disseminating mosquito and his allies. In the polar regions they are completely encased and internally heated to permit the toilers to bid defiance to the attacks of Jack Frost.

In some places where, fifty years ago, armies of men swarmed like ants in an ant-hill with their rockers and

sluicing boxes wresting surface yellow dust from the silt, but who have long since departed owing to the exhaustion of the open workings, these cumbrous craft have forced a passage. The greedy maw of the dredger, floating in a tiny dock which it has carved for itself, is devouring the soft soil at the prow, passing it through the plant compactly arrayed on the deck to isolate the myriads of yellow specks, and discharging the tailings in a fountain at the stern. And as the dredger moves forward agriculture follows in its wake. The land which the vessel is building up with the tailings is being planted with orchards where some of the finest fruit to reach our tables is raised. Truly the search for gold may be said to be invested with a strange and wellnigh incredible romance.

There is one feature associated with the mining of gold which has never been convincingly explained. This is the occurrence of the mineral in nuggets. As I have pointed out, this metal is widely distributed in the form of fine grains or flakes, either loosely associated with alluvial earth or else invisibly ingrained with quartz. But the nugget is something quite distinctive. As a rule it is either a solid lump of pure gold, or is combined with a certain amount of quartz or some other impurity. But in either case the mass is found in quite a detached form.

Australia is pre-eminently the land of gold nuggets. In no other part of the world are they found in such profusion, of such size, purity and weight. It was the recovery of a nugget, or rather the fragment of a reef at Hargraves, New South Wales, in 1851, which set the whole world agog, and which precipitated a wild stampede, while similar occurrences in other parts of the continent have created similar rushes at intervals. The mass found at Hargraves weighed

106 pounds. Seven years later another big find was made at Burrandong near Orange, in the self-same state which, when melted down at the Sydney mint, yielded over 1,182 ounces of gold valued at £4,389 8s. 10d. A third notable find was that made at Brennan, which realised £1,156.

Victoria is the State in which gold nuggets would seem to exist most freely. Indeed, at one time, they were being picked up so frequently as to lead to the impression that this State was indeed paved with irregular masses of gold. Wild excitement prevailed during the opening month of the year 1853. On January 20th a lump of quartz and gold was picked up at a depth of 60 feet. It weighed 1,117 ounces 11 pennyweight, and was christened "The Sarah Sands." Two days later in the same area—namely, Canadian Gully, Ballarat—another lump, weighing 1,111 ounces 15 pennyweight, was unearthed. On the last day of the month in question, Canadian Gully yielded a third chunk, which was christened "The Canadian." It weighed 1,619 ounces, and yielded 1,319 ounces 1 pennyweight 12 grains of pure metal.

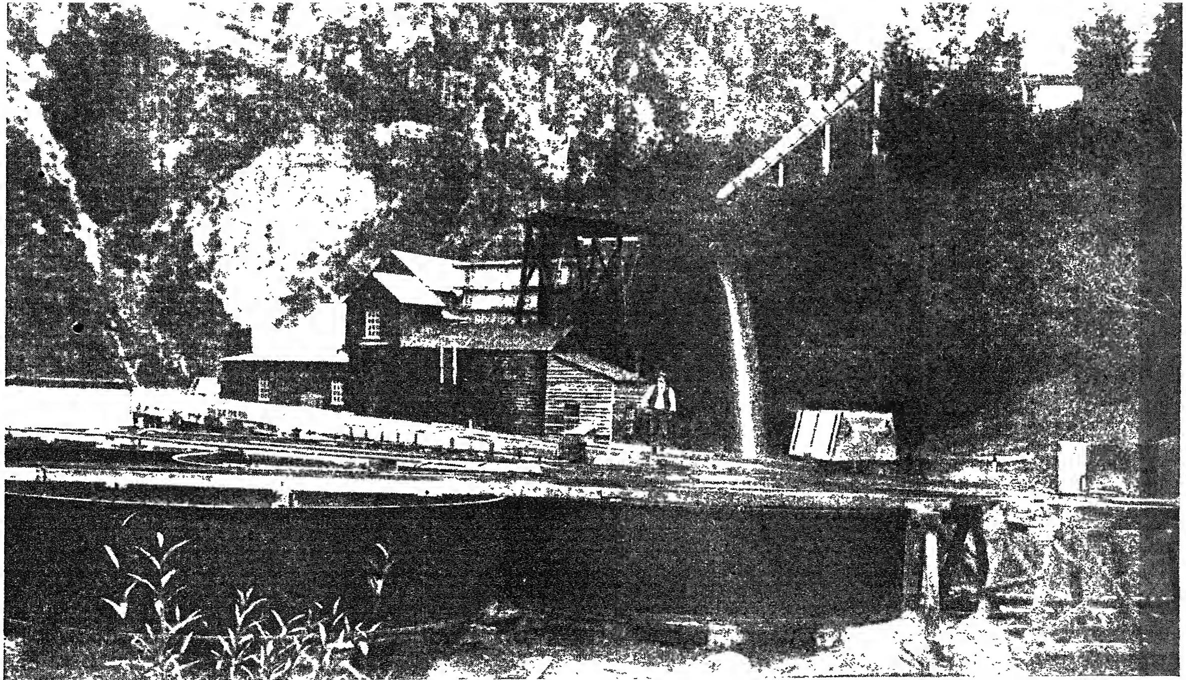
Excitement had partially subsided, when, in the autumn of the following year, "The Lady Hotham" nugget was brought to light at Dalton's Flat, near the spot where the previous masses had been unearthed. This weighed 1,177 ounces, and was additionally remarkable because the same hole yielded a number of smaller nuggets of an aggregate weight of 2,640 ounces, so that the miner in this instance struck luck in a patch as the gold-seekers say. The next big find was "The Heron" in 1855, a lump of pure gold scaling 1,008 ounces, followed three months later by another nugget weighing 1,034 ounces 5 pennyweight, which gave 833 ounces 14 pennyweight of pure gold. This was found only five feet below the surface. The year 1857 brought

"The Blanche Barkly" and another. The first scaled 1,743 ounces 13 pennyweight, while the second created the wildest enthusiasm since it was the biggest mass which had yet been unearthed, or of which any record was forthcoming, because this conglomeration of gold and quartz weighed 2,844 ounces. In point of weight and size it has never yet been equalled, although when reduced to metal it somewhat depreciated because the net weight of remunerative mineral was 1,363 ounces 18 pennyweight. In this instance the chunk of metal and quartz really comprised two nuggets, but it came as a highly attractive reward to the diligent seekers. The following year the Red Hill Mining Company, in the course of its work, came across a lump, "The Stranger," weighing 2,217 ounces, of which 2,195 was estimated to be pure metal.

For twelve years nothing approaching what had been recovered was recorded. Then on February 5th, 1869, came the most wonderful find of all. John Deason and Richard Oates stumbled across a huge mass of the royal metal lying in the rut made by the wheel of a passing wagon. It was lying only an inch below the surface, and it was the wheel, cutting into the soft soil, which had laid it bare. And what a find! When removed from its couch and weighed it scaled 2,520 ounces and gave over 2,284 ounces of gold. It was appropriately christened "The Welcome Stranger," and the spot upon which it was picked up is now marked with a stone obelisk. The next year, 1870, brought to light another mass lying at a depth of eight feet, weighing 1,114 ounces. This was named "Viscount Canterbury." In January, 1871, a Chinaman, Ah Chang, and his party, diligently scratching in Catto's Paddock, near Berlin, alighted upon "The Precious," weighing 1,717 ounces.

Since the discovery of "The Sarah Sands" on January 20,

1853, until the end of 1912 no fewer than 1,327 nuggets had been found in the State of Victoria, ranging in weight from 2,844 to 20 ounces. And the State's lucky bag has by no means been exhausted yet, because in 1914 a mass of quartz, yielding 94 ounces of gold, was found near the place where "The Welcome Stranger" had been picked up in 1869. The above total of nuggets unearthed, however, is scarcely likely to be correct. In the early days, when law and order were not maintained so effectively as now, finders were disposed to keep their discoveries to themselves, while to pick up a nugget did not always bring the result which one might have anticipated. Many prospectors were so overwhelmed by their "luck" as to have their minds unhinged, while the covetous did not hesitate to relieve a finder of his prize at the first opportunity. Consequently it is only logical to believe that many nuggets were picked up to which no trace to-day is forthcoming, the prospectors realising that silence, like their treasure trove, was golden.



By permission of the New Zealand Government

CRUSHING MOUNTAINS TO RECOVER GOLD

The quartz is ground to powder by stamps, the fine yellow dust recovered by amalgamation with mercury, the small proportion escaping such arrest being secured by passing the tailings through vats filled with cyanide of potassium, which seizes the fugitive specks of gold.

CHAPTER XI

Silver, Lead, Zinc, Nickel, Cobalt and Antimony

WHILE gold has become the universally recognised standard of currency, there are certain countries which prefer the silver coinage. As a result a silver standard has attained a vogue, and so from the commercial standpoint silver may be regarded as the second most important mineral. Mention of silver recalls the South American reign of the Spanish dynasty, during which this metal to the value of many millions of pounds was wrung from the heart of the Andes. While South America can still point to huge reserves of this mineral, and to the fact that many of the mines opened by the Spaniards are still being worked, it has been surpassed in point of output by other territories since the middle of the nineteenth century.

Among these territories few are of such importance, or can narrate such a story of absorbing romance as the American State of Colorado. Indeed, it might very appropriately be described as Uncle Sam's Lucky Bag, since it is saturated with minerals of infinite variety and in amazing abundance. For over half a century it has been a Tom Tiddler's ground to the prospector, the conditions being extremely favourable to the pursuance of his activities. At the time the Colorado boom was at its height no fewer than 75,000 of these hardy adventurers, more or less experienced,

were roaming the State, zealously scratching, probing and assaying the rock.

Physically Colorado is an amazing reach of territory. Practically the whole of the State is occupied by the Rocky Mountains, which here reach their highest altitudes. At the same time they are found in their most ragged and dishevelled form. Nature had a merry game when she fashioned this part of the country, and apparently grew weary in the process. At all events, it would be difficult to discover a parallel to towering peaks, with crown of ice and snow, jostling and striving mightily for premier recognition. In the shadows they cast are concealed deep yawning ravines, many of which are clothed in a perennial twilight, the floor never catching a beam of light from the sun. When the Rockies in this State were in the grip of the volcano the rumpus must have been violent and prolonged, for the layers of rocks are twisted, folded, bent, and doubled up in the most extraordinary manner. But those self-same rocks are permeated through and through with gold and silver of amazing richness.

If one would seek to secure an impression of Colorado's mineral greatness, one should consult the map. There he will see, about midway between the Atlantic and Pacific coasts, inscribed in somewhat heavy type, the name of the town Denver. The very fact that the type is heavier will suffice to indicate that Denver is certainly more important than the thousands of places scattered for miles around it. As a matter of fact, Denver is the oldest city of the Middle West. It might even be said to be the first city west of the Mississippi. It was a hustling well-ordered community before many another big American city of to-day was ever thought of, when the nearest railway station was

600 odd miles away, and when everything had to be carried to and from the city across the plains upon the backs of mules and pack-horses, or aboard a prairie schooner.

Denver was brought into existence by the mineral wealth of the State. When the rush to the Californian fields was at its height, many of those making their way across country to that lodestone were instinctively persuaded to abandon their original quest when confronted by this mighty rocky barrier, and to search for the precious minerals in the fastnesses of this wildly mountainous State. So California never saw them. Events proved their second reflections to be well considered, because these intrepid adventurers speedily discovered that, while the new gold-field might be rich, it must be stuffed with gold in very truth to excel in value and distribution the treasure trove to be found in Colorado. It was not long before many of those who had pushed ahead to the Pacific coast turned tail to retreat as far as this stretch of the Rockies to pick up the fortunes which had been denied to them in California.

But the early days in Colorado were exciting in the fullest sense of the word. It became the wild and woolly west in deadly earnest—a State of camps through which to ride fast was to invite a bullet to compel one to pull up so that stock might be taken of one's face; where fortunes were made in a day and lost in a night. The prospectors had an hilarious and rollicking wealthy time. Every yard of creek, stream and river showed colours. There was never any occasion for anyone to be without money for more than a few hours at a time. If one lost his all at the gaming tables, or was relieved of his fortune by a member of the light-fingered fraternity, one did not worry. One merely returned

to some lonely untrodden mountain slope and prospected anew, buoyed up with the knowledge that a "strike" was inevitable within a few hours.

Curiously enough the Britisher played a very prominent part in the unlocking of this treasure-house of Nature. He was among those who first found any signs of the unsuspected mineral wealth, and in prospecting and mining he acquired a high reputation. Then, when the stage was reached for the newly discovered mine to be developed, it was generally British capital which supplied the necessary sinews of commerce. I have already told the story of how Weston and his friend, an Anglo-American partnership, discovered the Camp Bird Mine, but there are dozens of other properties bristling with similar romance.

One has only to pause to reflect upon the picturesque nomenclature of many of the mines, towns and other centres to realise the wide distribution of wealth. These quaint names offer a convincing index to the character of the metal which was responsible for the foundation. There is Silverton, the town where the smelting of silver became the primary occupation; Leadville, where the seams are rich in a silver lead; Telluride, which also savours of a metallic association. Then there are the names of the mines themselves, such as "Pride of the West," "Wagon Wheel Gap," or the gap (in the mountains) where the wagon wheel (of a prospecting outfit) was found, Silver Cliff, the "Racine Boy," Carbonate Hill, Buckskin Joe, Wheel of Fortune, Aftermath, Crested Butte, Copper Creek, Crystal City, "Oh be Joyful Gulch," "Poverty Gulch," and so on. In naming his claim the quondam miner and prospector was always quaint, and the title invariably was identified with some phase of industry, effort, incident, or emotion.

Silver, Lead, Zinc, etc.

Stories of sudden and sensational accretion of wealth untold alternate with harrowing tales of hard luck. While the majority of the romances are naturally associated with the more eagerly sought yellow metal, silver played its part, especially around Silverton and Leadville. The development of the "Aspen" mine in the San Juan country nearly precipitated a terrible disaster. The mine is situate high up on the mountain, and in those days could be reached only by a road which zigzagged up the cliff face. Winter settled down far earlier than usual, and before the community around the mine had been able to secure the winter stocks of provisions which were on the way. Before New Year's Day arrived the amount of food in the place would not have stocked a small shop. Hotels provided beds but resolutely refused to supply visitors with board. There was not a ham, a pound of flour, a rasher of bacon, or a pipeful of tobacco in the colony. There was a debate, and the risk of starvation being imminent, it was decided to make a concerted rush for the outside and to incur the risk of death in the snow, by snowslide or exhaustion, despite the fact that the journey to the nearest settlement involved the negotiation of 100 miles of the toughest country in the State. When all appeared to be lost one of the big mines suddenly closed down. This was regarded as a calamity of fearful portent. It was learned, however, that the mine had followed this course to enable it to dole out its reserves of food among the community to better advantage. Work would have created too healthy an appetite to be assuaged by the short commons remaining, and in this way the little colony held out until the winter broke.

Colonel Baker, an officer in the Confederate Army, organised a prospecting party to examine the highly situated

reaches of the Pike's Peak belt. They gained their objective and silver was found in plenty, but they could not work it. The winter trapped them, and they made themselves snug for the dreary months in an icebound prison. They were not perturbed, because a provision train was on the way to the camp. But hostile Indians raided the convoy, captured it, and from the intelligence gained decided to harass the weather-bound prospectors. The little party, about two hundred in all, became reduced to the verge of starvation, and, to make matters worse, sickness broke out. Even the stoicism of the prospectors broke down at this sorry trick of fortune. They turned upon their leader, denounced him as a cheat for landing them in such a mess, and decided to hang him forthwith. As they were leading him to the noose slung from an adjacent pine a visitor arrived with a little assistance, which sufficed to tide them over until the summer reappeared, when a remnant of the party crawled back to civilisation. The others had died.

The land prospected by the party acquired such a sinister reputation from this tragic end to a well-equipped expedition as to be sedulously avoided for five years. Then a prospector, so daring as to laugh at superstition, forced his way to the spot where Baker had toiled unsuccessfully. A few weeks later a mild rush set in from the discovery of silver which brought about the creation of Howardsville, and provided the occasion for the foundation of Silverton. For some time the town was a bed of lawlessness and crime. Then the sober citizens organised themselves into a Vigilance Committee and set about ridding the town of its pests. Tempted by a reward the bosom comrade of the ringleader betrayed his "pard," who was rounded up, tried, condemned and hanged, the unsophicticated frontier mining-camp jury

declaring in their verdict that the unfortunate criminal met his death "from hanging-'round!"

When Leadville was ushered into the history of things that are, the mineral development of Colorado went ahead with a rare swing, because, by one of those strange tricks of Fortune, the coming of the town had been delayed by nineteen years. In 1860 placer gold was found in the district. There was a rush of 10,000 people to the spot, and during the three summer months gold worth £500,000 was washed out. One of the pioneer prospectors carried out a bagful of gold-dust weighing 29 pounds, and sold his claim, which he said had petered out, for £100. The new purchaser, however, stuck to the claim and took another £3,000 out of it in twelve weeks. However, the frenzied gold-seekers were worried by one peculiarity in working the placers. When panning, rocking and sluicing, a mass of black sand sunk to the bottom, clogging everything. It appeared to be as heavy as the gold itself. It was thrown away in disgust, and the extent of its occurrence probably had a good deal to do with the abandonment of the camp. Be that as it may, every seeker left it, their pockets and gunnysacks bulging with gold. To indicate how prolific was the precious yellow dust, the last party to leave the camp, before departing, decided to demolish the old gambling saloon. Here they found an amount of yellow dust lying on the ground which they promptly panned, netting £400. This was dust which had been dropped by the gamblers while sitting at the tables.

In 1876 a prospector was tempting fortune upon the old site. He was down on his luck. He went out with his gun to secure a much-needed breakfast for his equally poverty-stricken partner and himself. He brought down a deer which in its death struggles ploughed up a mass of the mysterious

black sand. The curiosity of the two prospectors was aroused. Not being able to determine the character of the sand they staked a claim to make sure of their property, doubtful though it was, should subsequent assay prove the ore to possess any value. In 1877, the following year, another shrewd miner, named Wood, happened to be in the vicinity, and his attention was drawn to this curious black sand. He communicated his find to his colleague, and assay proved the sand to be rich in silver. The two thereupon concluded that the source of this sand drift must be somewhere in the vicinity, and so they set out upon a systematic search, and at last arrived at a point which they decided must be the location of the lode. They started to sink trial shafts, to the intense amusement of the placer miners still working in the vicinity, and whose ire was raised by the occurrence of the sand. They called the two shaft sinkers a couple of fools, but the seekers were content to be the butt of ridicule and jest. At last they struck the lode by driving through the limestone.

There was a wild stampede to the district, the "strike of silver" in huge quantity firing the imagination of treasure-hunters for miles around. A stream of humanity poured into the gulch, which was speedily over-run from end to end. Wood and Stevens sought diligently for labour to start their works, but the frenzied seekers were too intent upon prospecting for individual profit to consider the tempting wages which were offered. Accordingly Stevens went home to Detroit to recruit labour. He secured plenty and brought his force to Leadville, or as it was then facetiously called, "The Camp of the Carbonates," from the association of the silver with the carbonate of lead. Wood and Stevens, however, received a rude shock. Winter brought work and

Photo. by permission of the South Australian Government.

BARS OF SILVER LEAD READY FOR EXPORT FROM PORT PIRIE, SOUTH AUSTRALIA

standstill and the unemployed recruits began to grow discontented, finally turning on their employers, imprisoning them in a cabin, holding a mock trial and condemning them to death by hanging. At the critical moment a capitalist appeared on the scene, assuaged the angry crowd with money, and so restored peace.

The news of a great silver strike had become known far and wide throughout the continent, and streams of humanity commenced to converge towards Leadville. They came as far as the railway could bring them, and then set out to make the last 100 miles over the still snow-bound mountains which were nearly impassable by whatever conveyance they could acquire. Thousands toiled afoot to the camp nestling some 11,000 feet above the sea, and suffered privations and hardships of a terrible nature for their intrepidity. The stage coaches did a roaring business, charging their frenzied fares 7½d. a mile, while the packers charged 5d. a pound for all they took in. Everything soared to famine prices. New arrivals poured in at the rate of 200 a day. Accommodation was scanty and sleep was snatched wherever it could be found.

Prospecting was carried on at every likely and unlikely spot. Some men toiled in solitary state; others scoured the mountain slopes in pairs; while many banded themselves into small parties. There was one small party, a member of which succumbed to illness during the winter. His comrades hired a man to dig a grave, the terms being £4. Seeing that it entailed driving through ten feet of solid snow and six feet of hard frozen ground the payment was not excessive. From lack of better accommodation in the one-roomed shack the body of the dead comrade was laid in a snowbank. The companions waited for three days, and then went off to see how

the grave-digger was getting on. They found him in the hole, but much deeper than the prearranged six feet. He declined to budge. In digging the grave he had alighted upon a vein of silver and had decided to abandon his designed task and to turn the intended grave into a mine. He was bringing out ore averaging 60 ounces of silver to the ton, and would stick to his claim, come what may. Nonplussed, the miners did not attempt to hold the man to his bargain. In the excitement the dead chum was forgotten, his comrades being too busily occupied in sinking shafts in the vicinity of his projected final resting-place. They did not think of him again until the snow vanished and left his corpse stranded high and dry.

Another party of miners, satisfied with what they had achieved up to a depth of 150 feet, decided to sell out. They offered a half interest in the work to some capitalists for £2,000, stipulating that the money should be paid over before five o'clock in the afternoon. Half an hour before the appointed time they struck another and richer vein of silver. At half-past five the capitalists came along leisurely, and proffered the prearranged sum. The spokesman of the prospecting party shook his head in refusal, and, pointing to his watch, indicated that the men of money were half an hour behind time. "But," he continued, "you can have the half-share as arranged for £12,000!"

In this way the prospectors were enabled to retract from what would have proved a magnificent bargain for the capitalists but a bad one for themselves.

As a rule, in fact almost always, silver is associated with several other minerals, such as lead, copper, cinnabar, from which quicksilver is obtained, copper, antimony, arsenic and other commercial minerals. In the past, when the ore was rich in silver, this was the only mineral to claim attention,

but nowadays, owing to the great scientific strides which have been made, other minerals are reclaimed. The processes involved are somewhat intricate, and vary according to the complexity of the ores. One of the most complete plants in this respect is that installed at the Broken Hill Mine, New South Wales. This mine is located upon one of the finest argentiferous lead-ore deposits in the world, extending over 2,500 square miles. It was brought to light in 1883 by Charles Rasp, boundary-rider on Mount Gipps Run. The Broken Hill lode, as a result of subsequent survey, was found to run continuously for several miles and to range in thickness from 10 to 200 feet, rendering it one of the largest silver deposits ever found.

In this instance the ore is also appreciably impregnated with zinc, and, as a result of prolonged experiment, a means of recovering the zinc as well was found. This increased the value of the property very considerably, because now an opportunity was offered to subject to treatment the tailings, which had accumulated during a period of twenty years, merely to recover the zinc which they still carried. Spelter commands a high value, so that by the discovery of the zinc recovery process what was virtually a new mining property was created. It is not often that an immense extent of rubbish so suddenly becomes transformed into a valuable commodity. In this instance the waste-dumps became as valuable as the mines themselves when considered from the single mineral point of view. To indicate the complexity of the silver ores it may be pointed out that the commercial metals extracted from the lodes exploited at the Broken Hill mines include silver, lead, copper, zinc, tin, antimony and gold. Everything possessing commercial metallic value is secured.

To bring home the wealth of this property it may be mentioned that by the time this mine attained its majority it had treated 8,593,460 tons of silver and silver-lead ores, from which was derived 137,334,965 ounces of fine silver and 825,949 tons of lead valued at £30,620,000. In 1883 the district in which the mines are located was occupied by only a few station hands. Twenty-one years later there was a thriving town of 28,250 souls, of which total 8,457 were occupied at the mines. When the zinc recovery process was sufficiently perfected to permit introduction there were more than 5,000,000 tons of "waste" available for re-treatment, and it was estimated that these dumps, in addition to carrying over 1,000,000 tons of zinc, were also impregnated with 34,000,000 ounces of silver and 380,000 tons of lead, the greater part, if not the whole, of which it now became possible to recover. The world's consumption of silver is far greater than might possibly be believed. In 1914 the total production from all the mines in activity was set down at 211,103,000 fine ounces, of which Australia's share was 3,520,000 ounces, or about 1·7 of the aggregate. Production varies widely inasmuch as the price of the commodity is subject to extensive fluctuations. Thus, whereas the price stood at 4s. 3¾d. in 1881, it dropped to less than 2s. an ounce in 1909, the lowest average since 1881. Even in 1915 it was worth only approximately 2s. an ounce, but in 1919 it soared to more than 4s. an ounce.

During the past few years Canada has come into the market as a silver producing country, this being due, in the main, to the sensational discoveries made at Cobalt a few years ago. Of the 167,000,000 fine ounces which is stated to represent the world's total output for 1917, Canada occupied second place with 22,150,680 ounces, the United States

being first with 74,244,500 ounces. For many years Mexico led the world in the production of this metal, the annual yield being about 70,000,000 ounces, but its output has fallen by approximately fifty per cent. as a result of the internecine strife and general unsettled state of the country.

Reduced output and increased demand have been responsible for the high prices which the metal has commanded. On September 28th, 1917, the Mining Corporation of Canada sold 200,000 ounces at $\$1{\cdot}16\frac{7}{16}$ per ounce, the highest figure touched for forty years. India and China were mainly responsible for this sensational rise, their purchases running into unprecedented figures, not only for coinage, but also for use in the arts. As a matter of fact, the East absorbs about 70 per cent. of the world's production every year. During the fiscal year ending March 31st, 1917, the Indian mints turned approximately 106,000,000 ounces of silver into coinage amounting to 307,750,000 rupees. It was in order to relieve the exceptionally strained situation which developed that the United States Government decided to melt down silver dollars to the value of £80,000,000, which it held in reserve against its paper money, to be placed upon the market in the form of bullion as occasion demanded.

The value placed upon the metal is somewhat extraordinary, more especially when it is remembered that about two-thirds of the world's supply is recovered as a by-product. Many mines, if restricted to the mere extraction of silver, would have to close down under normal conditions, because of the impossibility to work the silver at a profit. This is demonstrated by the fact that the output of silver does not rise proportionately to the demand which would otherwise be the case were it the primary mineral. Similarly, if silver were to become worthless, the mines whence supplies are

derived would not have to close down; the revenue earned from the sale of the other products, such as lead, copper and zinc, would suffice to keep them going.

One of the few districts in which argentiferous ore is worked primarily for its silver is the province of Ontario in Canada. In 1904 there was a frantic rush to the Lake Temagami country. Silver had been discovered in astonishing abundance. A timber town sprang up at Cobalt virtually in a night, and there was a wild wave of speculation. Rich big veins of the lustrous metal were struck, some only a few inches below the surface. From the surveys which were made it was only too evident the rich silver lodes intersected the rock in all directions.

It was speedily discovered that in mining the silver it would be necessary to bring to the surface other materials such as cobalt, nickel and arsenic, for which there was only a severely limited, if any, market. However, development work soon commenced in grim earnest, the ore being torn out and shipped to the United States to be treated, where the cobalt and other substances were eliminated and thrown away. The shipment of the ore to the smelters in the country next door, however, was construed as being a fallacious policy. It was to the interests of the industry that the refining of the metal should be conducted in the country itself so as to secure the full advantages accruing therefrom. Accordingly a metal refining bounty system was introduced by the legislature, which authorised the payment of a bounty of 3d. per pound, calculated on the metallic content, on all cobalt and nickel smelted in the country. The bounty was to remain in force for a certain period, the object, of course, being to encourage the establishment of native refineries. This procedure accomplished another useful purpose. It

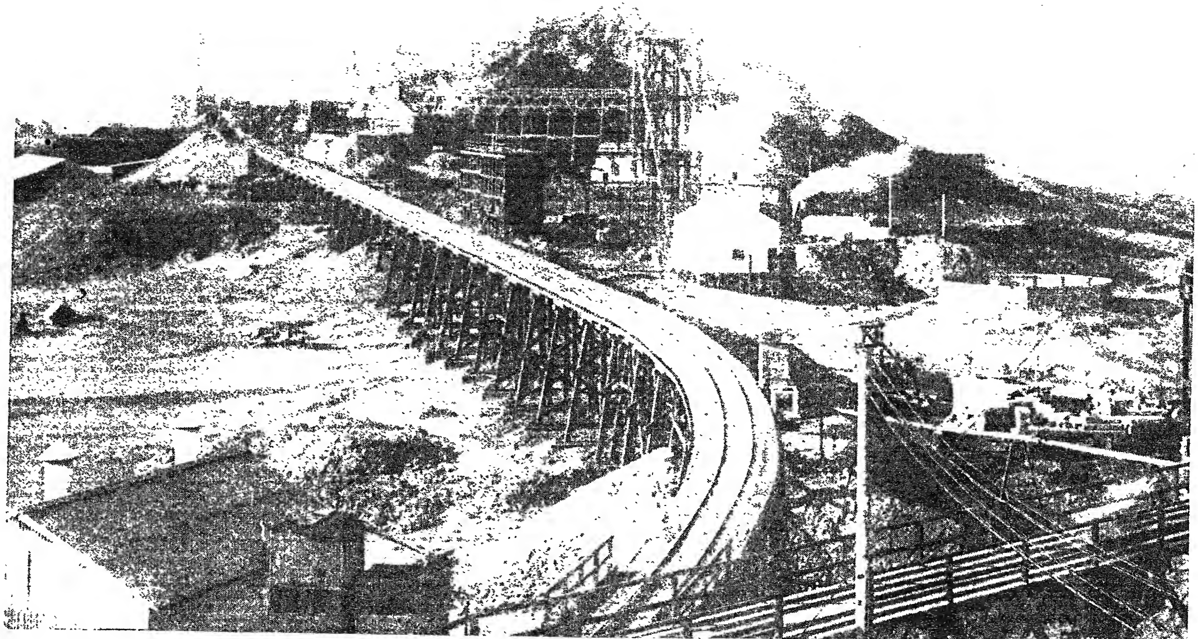
encouraged the reclamation of the various other substances associated with the primary products, and, as a result of sustained experiment and research, commercial uses for these "wastes" were found.

Cobalt itself was only slightly in demand. It was mainly used as a colouring material—cobalt blue—in the manufacture of fine pottery and chinaware, notably in Europe. Supplies of this commodity were derived from New Caledonia, a small French island off the Australian coast, which was quite capable of meeting all commercial requests, and which had also established a firm position in the market, although the price was relatively high, being about 10 shillings a pound. The Canadian refiners, being compelled to save the cobalt waste from silver smelting, thereupon decided to compete with the New Caledonian product. It held the advantage in price, but for some time failed to make pronounced headway, although appreciably cheaper, the European users having become so wedded to the French article as to refuse to believe that the Canadian product could possibly compare with it in point of quality.

The factor of price ultimately gained the day, the Canadian producers forcing the cost of the article down from ten to three shillings a pound, a figure which was hopelessly impossible to the New Caledonian interests. It was a stern uphill fight while it lasted, and the Canadian victory, while deserved, was influenced to a certain degree by unblushing trickery practised by certain manufacturers and dealers in Europe. The last-named were convinced of the quality of the cobalt blue from Ontario, but they could not persuade their clients to a similar line of appreciation. They had always used New Caledonian smalt, and they would continue to do so all the while it was obtainable. It was merely a

secured, to-day the products recovered from the ore include cobalt and nickel oxide, cobalt sulphate, carbonate and hydroxide, nickel sulphate, metallic cobalt and nickel, stellite—the alloy—and arsenic in the form of white arsenic, arsenious acid, and a small quantity of metallic arsenic. The wonderful growth of the industry is reflected by the results of operations. In 1904 only four mines were at work, from which 158 tons of ore were raised, yielding 206,875 ounces of silver valued at £22,377. By 1910, when the field was six years old, the number of mines had been increased to 41, which between them raised 27,437 tons of ore, yielding 30,645,181 ounces of silver worth £3,095,609. Up to the end of 1917, as a result of 14 years' work, and the subsequent development of the by-product minerals, treasure valued at £31,635,268 has been torn from the earth around Cobalt, of which £30,390,132 was represented by silver, the total quantity of which to be recovered was 274,724,172 ounces.

Not many miles from the cobalt country is another mining region of equal significance. This is where nickel, the close ally of cobalt, is found in attractive quantities. This treasure trove was unearthed while the Canadian Pacific Railway was being driven through Sudbury, Ontario, on its way to the Pacific coast. Curiously enough, however, it was not the nickel, but the copper with which it is associated that attracted the attention of the prospectors. Assay of the specimens showed a wide fluctuation in the percentage of copper, and when the ore was shipped to the United States to be smelted unexpected difficulties were encountered. The obstacle was found to be the nickel, and closer examination proved that the ore was richer in this metal than in copper, the average content being 3·5 per cent. of nickel and 2 per cent. of copper. The occurrence of the two metals imparted



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SILVER MINING AT BROKEN HILL

To explore thoroughly this rich mine would require many days, for the shafts, drives, levels, and adits may be measured in miles.

an increased value to the ore, and, as the value of nickel came to be appreciated, especially by the steel industry, development went ahead rapidly.

Owing to the increased demand for nickel to meet the various needs of war, especially in Italy where it is extensively utilised in the manufacture of aeroplanes, extraordinary activity in the mining of this metal was recorded, the output practically being doubled during the five years 1913-17. In the former year 823,403 tons of ore were smelted producing 47,150 tons of Bessemer matte, which in turn yielded 24,838 tons of nickel worth £1,047,495, and 12,938 tons of copper valued at £367,887, a total of £1,415,382. In 1917 1,536,828 tons of ore were raised, of which 1,453,661 tons were smelted, yielding 78,897 tons of Bessemer matte. Subsequent treatment extracted from this matte 41,887 tons of nickel worth £4,188,700, and copper set down at £1,568,578—a total of £5,757,278.

Under the Refining Bounty Act native smelters and other plants for preparing the metal were established upon the spot. One of the largest companies exploiting this mineral is British, having large works in Wales, so an appreciable quantity of the metal is shipped to this country to be worked up for the market. The ore, upon being raised to the surface, is roasted for the most part in heaps in the open air, and in 1917, to carry out this phase of the operations, the surrounding forests were called upon to furnish approximately 29,000 cords of wood. As a cord of wood represents a stack of logs, cut to 4-feet lengths, piled 4 feet high by 8 feet in length, the cubical content thus being 128 cubic feet, it will be seen that to roast the nickel ore during the year in question 3,584,000 cubic feet of wood were consumed, which will serve to convey some idea of the levy imposed upon the Canadian

forests to satisfy the needs of this industry. For smelting, blast furnaces and converters are employed, the process being broadly similar to the Bessemer process used in the manufacture of steel—hence the description of the crude metal as Bessemer matte. Subsequently this matte is refined, which not only enables the two metals to be isolated and recovered individually, but purges them of the other foreign substances which may be present. While the nickel in its metallic form is extensively employed in the steel making and electroplating industries, an appreciable quantity of nickel sulphate is produced, this having been found eminently adapted to the hardenings of oils and fats (as the process of imparting a solid character to such naturally fluid substances as fish oils is called) which enter extensively into the preparation of margarine.

Another metal which plays a prominent part in various industrial operations, but probably scarcely known to the average person except in connection with the arts, is antimony. It is certainly a minor metal but one of distinct value, because it enters into such a diversity of industries. As a means for hardening lead it is unequalled, and accordingly is extensively used in this connection. There is a remarkable affinity between lead and antimony, and for this reason lead is generally employed for recovering the antimony from any other mineral with which it may be associated. The lead is introduced into the plant and the antimony which is present instantly attaches itself thereto, forming what is known as antimonial lead. No effort is made to separate the two subsequently, because, so long as specific proportions are observed, each metal is improved in its essential characteristics by the presence of the other. Among the many materials, into the composition of which it enters, may

be mentioned anti-friction metal, britannia metal or German silver so freely used for the manufacture of teapots and other domestic articles, type metal, acid tank linings, while in the salt and oxide forms it is employed for a wide range of further purposes, including the ceramic and enamelled iron-ware trades. In so far as munitions are concerned it has far more uses, especially in the preparation of small arms ammunition.

Although antimony is found in large quantities in its distinctive ore, stibnite, an appreciable quantity is extracted from the ore-bearing silver and gold. The world's output is relatively small, and apparently it has been distributed somewhat sparingly. It is a bright silvery metal, but in its pure form exceedingly brittle and readily pulverised. This is the reason why it is invariably associated with some other metal to form an alloy, in which form it is of far greater utility to commerce and industry. It is extracted from the ore by a number of processes, the first stage being one of simple fusion. Raw antimony suffers from being combined with certain deleterious substances, such as arsenic and sulphur, which need to be eliminated, and to achieve this end the stibnite is placed in the furnace with limestone and scrap iron. Fusion completed, the molten mass is run into moulds and is then subjected to refining.

The country from which the world's principal supplies are drawn is China—in fact approximately 75 per cent. of the antimony used comes from that country. The mining of this ore is an old established Chinese industry, and the output aggregates about 12,000 tons a year. Shipment is largely confined to the crude ore, the extraction of the antimony being carried out at the smelters and refineries of the country making the purchase. Mexico furnishes a certain

quantity, as also do Canada, France and South America. During recent years Australia has entered the market and increasing quantities are being derived from that continent, the Broken Hill mines being the principal contributor. From the geological surveys and systematic prospecting which have been made, the metal appears to be widely distributed in the north-eastern corner of New South Wales. At Broken Hill it has been found in association with silver, while at Hillgrove it is found with scheelite and gold.

Among other minor metals which are found in small quantities in various corners of the world may be mentioned chromium and bismuth, as well as some of far more importance, but which from the severely limited nature of supply are regarded as belonging to the rarer metals, to which reference is made in another chapter.

CHAPTER XII

Digging and Fishing for Amber, Gum and Jet

AMONG the many products of the earth to be highly prized, and for which search consequently is keen, may be mentioned amber. As a decorative and ornamental material it occupies a peculiarly high position, but at the same time it has a distinctive position in the commercial world, a particularly high-grade varnish being made therefrom. However, the quantity diverted to this purpose is comparatively small, and for the most part it is the waste of parings which are submitted to such utilitarian use.

Amber may be described as a mineral, but differs from those with which we are more familiar in many respects. It is actually a fossilised resin of a coniferous tree, which flourished on this earth a few thousand years before the advent of man. To a certain degree it is an enigma to science, the vegetable origin not yet having been determined with certainty, but that it once was fluent is obvious from the discovery of insects embedded in the fossilised substance. It is only possible to explain the occurrence of the "fly in the amber" from the fact that when the tree to which it belonged was flourishing the resin was somewhat similar in consistency to honey, though far more sticky.

This treasure, the "elektron" of the Greeks, and from which the term electricity is derived owing to the discovery that amber becomes highly negatively electric when rubbed

violently, is found in various parts of the world. Specimens have even been found off the East Coast of these islands, brought in by tides and currents, while it is occasionally come across when digging in chalk, gravel, shale and coal. To the mineralogist it is known as "succinite," and the finest specimens are those found in Sicily, the colouring of this variety being particularly beautiful.

The principal source of supply, however, is the coast of the Baltic Sea, more particularly in the vicinity of Königsberg. Even in ancient times this constituted the "Kimberley" of the amber world. At this place it is freely washed up by the sea, especially after a violent storm, and this fact, coupled with the demand which prevailed for the substance, and the high prices which it commanded, acted as a further incentive to fishing zeal among the inhabitants of this part of the coast. Amber fishing developed into a somewhat impressive industry, and is even continued to this day, the fishermen using large nets, with which they trawl the shallow waters after a storm, much after the manner of our native shrimpers. The harvest naturally varies: the more violent and destructive the storm to property on shore, the more likely is there to be a heavy haul of amber, which the elements in their fury, tear from the so-called "blue earth" in which it is imprisoned and which forms the sea-bed. Thus, in January, 1914, the Königsberg district was assailed by a heavy storm of exceptional ferocity, accompanied by a high flood tide. Considerable havoc was wrought, but the assault of Nature was regarded with ill-disguised delight by the local fishers, because they brought in some highly valuable prizes of the fossilised resin.

Amber fishing, in fact, is almost as important an industry as that associated with the trapping of foodstuffs from the

sea, and the "nuggets" which are sometimes brought in create as big a commotion as the unearthing of a large ragged mass of pure gold in an alluvial bed, or the unearthing of a large diamond. For the most part, however, the amber is recovered in small lumps, it being very exceptional to alight upon a piece scaling ten pounds in weight. In Berlin there is a "nugget" weighing 15 pounds which is valued at £1,500, while the largest piece ever secured of which there is any record weighed 18 pounds. Another fisherman found a lump weighing 13 pounds in his net and the sum of £1,000 was promptly offered for it, but the tempting reward was equally promptly refused.

The frequency and more or less regular recurrence of the value of the harvest prompted scientific investigation, and it was found that the strata forming the bed of the Baltic continued through a cliff about 160 feet in height forming part of the coast line. Accordingly mining for amber developed into a recognised industry, and has been practised since 1860. But the industry has never attained impressive proportions, due no doubt to carefully deliberated intentions to restrict supply and thus maintain the high market price.

Mining and fishing for amber was taken under the stern wing of the Prussian Government, an official factory being established to conduct and control every branch of the crude trade to ensure a really powerful monopoly. Fishermen and others, discovering amber upon the seashore or recovering pieces from the waves, are under a strict penalty to surrender it to the authorities. So rigid are the laws concerning the disposal of crude amber as to render the fisherfolk afraid to dispose of any of their discoveries to strangers. Even firms specially concerned with the working of amber are

forbidden to treat with the fishermen to obtain supplies, and the regulations are so relentlessly enforced as to render illicit amber buying extremely precarious both to buyer and seller. But to maintain the fishing zeal of the toilers of the sea the authorities drew up a scale of payment for the acquisition of amber brought in by the fishermen, this being based upon an arbitrarily settled estimate of the value of the raw product.

The visitor to the amber refining works might be pardoned for thinking that he had wandered into the Kimberley diamond mining territory by mistake. The precautions observed for preventing theft and loss are every whit as exacting. The miners are searched before leaving both the works and the mines lest they may have secreted pieces in their pockets. The women who work and prepare the amber at their homes have the crude material entered up against them to the uttermost carat, and, when they surrender their work, both the cut portions and the parings are weighed, the total of which must coincide with that of the raw piece issued to them. It is no fault of the Prussian Government if any illicit trading takes place, because every conceivable precaution is observed.

As far as mining is concerned this is restricted to activity at a single place—the Anna mine at Palmnicken. Both open and underground working is practised. For the latter shafts are carried down to the blue earth which is a regular seam ranging from 13 to 24 feet in thickness. Galleries are driven in all directions from the bottom of the shafts and the roof and walls are heavily timbered. To protect the open workings from the ravages of the sea the foot of the cliff is heavily protected by massive stone dams.

The underground workings are somewhat extensive and

afford employment for several hundred miners. The blue earth is broken down by pick and shovel, and the pieces of amber which are found are transferred to bags, each man surrendering his haul upon leaving the workings. The blue earth as removed is carried to the surface by horse-drawn carts, and, upon reaching the top, the spoil is dumped and submitted to a washing process. The water speedily disintegrates the earth, carrying it away through a grid, the pieces of amber thus being left upon a grate. The system, it will be observed, is somewhat reminiscent of that followed with the cradle and rocker in washing for alluvial gold. When the amber is recovered it is submitted to a further washing, leaving it quite clean. It is then sorted or graded, after which it is then dispatched to the Royal Amber Works in Königsberg where it is given a final clean, graded and stored against issuance for subsequent operations, no actual working being carried out in the Royal Factory itself.

To fire the zeal of the miners premiums are awarded for particularly good finds, but, as already pointed out, lucky discoveries are few and far between. Owing to the frequency of accidents from collapsing galleries, underground mining is being slowly abandoned in favour of surface workings. Large mechanical excavators are employed for digging the blue earth, while this is loaded directly into railway wagons for transference to the ore-washing plant, the mud being allowed a ready escape to the sea, leaving the amber behind. To Königsberg the industry is of distinct importance, no fewer than 500 women finding steady employment in normal times.

Another mineral of the "gum" group which has distinct value as an ornament is jet, the trade in which, so far as these

islands are concerned, is centred in Whitby. Unfortunately the industry is one which has decayed somewhat pronouncedly during recent years as the result of foreign competition and from the use of substitutes. Here again science is not quite decided concerning the origin of the material. In certain respects it resembles amber, and in Germany is found in the same clay which yields the fossilised resin. In many respects it resembles lignite or brown coal; again it is not unlike oil. As a matter of fact, jet is considered in many quarters to be more closely allied to oil than to coal, especially in view of the fact that it is found for the most part, notably in this country, associated with the shales.

Jet is found in two forms—hard and soft respectively. The former is that in greater request, and consequently is the more valuable. It is found in somewhat irregular form, often in fissures of rock, confirming the theory that it was once fluid, and by virtue of this property was able to gravitate into such spaces to undergo solidification by pressure. As a rule it is only recovered in small pieces, the largest mass ever found, so it is stated, measuring 72 inches in length by 6 inches wide, and weighing about 12 pounds, which found an ultimate market at 25s. a pound.

The British industry was established at Whitby about 120 years ago, although, of course, the use of this material for ornamental purposes has been followed for centuries. During mediæval times the Whitby mineral was much in demand, but no organised methods of exploiting the resources appear to have been employed. In the nineteenth century the decorative mineral appreciated in popular estimation, about 200 workshops being in operation in the Yorkshire district in the early seventies. The more cheaply produced

foreign product, and the use of imitation materials, hit the trade somewhat adversely, with the result that it has languished, while its funereal colouring is doubtless a formidable obstacle to overcome in any effort to establish its widespread popularity as an ornament.

Somewhat primitive methods are followed in recovering the jet-rock. Either the face of the cliff in which it is to be found is broken down and the fragments picked out from the debris, or else small tunnels are driven into the hillside traversing the stratum in which it rests. But, generally speaking, the deposits are small, and consequently the venture is decidedly speculative. For this reason, and the relatively low price which the product commands, mining for jet has never been carried to a high stage of development. Upon recovery the outer crust or layer is removed by the aid of chisels, only the interior sections being suited for manufacturing purposes.

Another product of the fossilised resin family is Kauri gum, which is in keen request for the preparation of varnishes, metal and other polishes, paints and protective, cleansing and decorative mediums of wide variety. This resin, in reality, is the solidified turpentine of the Kauri pine, the tree indigenous to New Zealand. In fact, this corner of the British Empire has a complete monopoly of this fossilised product, since it is to be found only in North Island. Precisely when the utilitarian or commercial value of this resin was first established is obscure. One thing is certain. It was not a discovery of the white man because the Maoris, the native race of the island, were aware of its peculiar virtues and used it to a certain degree. They also knew where and how it might be recovered, and, as a matter of fact, still play a prominent part in the industry, which has

been set upon a more or less firm basis, though the manner in which it is conducted in the main savours somewhat of the primitive.

The commercial possibilities of the substance first aroused the white man's interest in the early forties of the nineteenth century, and export commenced about 1847. At first the market was relatively restricted while the price ruled low. For many years it hovered around £5 per ton, and then slowly, but persistently, rose until approximately twice the foregoing figure was accepted as the ruling quotation for the product. To-day it fetches from £50 to £60 per ton, and the price is relatively firm, the lower qualities, such as are recovered from swampy and periodically water-logged areas commanding the lower figure, while the better grades extracted from the higher-lying and drier ground fetch the higher price as might naturally be supposed. In many respects the superfine qualities recall amber, which is not surprising when it is recalled that the tree belongs to the big pine family.

Many centuries ago North Island was covered with dense tracts of Kauri pine, from the trunks and main branches of which oozed a sticky, slowly-moving, viscid honey-coloured liquid. If one closely examines the pines growing in a British forest to-day a similar liquid will be found exuding from the trunks. This liquid suffered oxidation upon exposure to the air, became sluggish in its movement, and gradually collected knots and balls and ragged lumps. In course of time it became very dense and hard, losing all its original plasticity, but shattering as readily as glass when struck with a hammer. A fire swept the forest killing the trees. After the fire had completed its deadly work a fierce wind came along levelling the gaunt trunks to the ground.

Then the microbes of decomposition attacked the prone dead giants of the forest, reducing them to powder or humus. But the microbes of decomposition did not attack the knobs of resin, these being completely resistant to all such attacks. The nodules fell away from the trunks upon which they had formed to settle like stones in the humus. In course of time another forest grew up, the trunks of the trees of which became covered with similar regular and irregular masses of resin. This forest in due course shared the fate which befell its predecessor and likewise became reduced to humus, forming a second layer, with interspersed lumps of resin, upon that which had already gone the way of all things organic. Through the passage of centuries this cycle of growth, destruction by fire and tempest and decomposition of the forests was continued unceasingly, with the result that to-day there is a huge and deep blanket of humus covering what was originally the virgin soil. Consequently knobs of gum are to be found in a series of successive layers. Precisely to what depth the gum-bearing stratum continues has not yet been fathomed. It varies of course according to the lay of the land. In some places it is only twelve feet or so in depth. In others excavations have been carried down to 25 feet, but without touching bottom.

This area of forest covers an immense tract of about 800,000 acres. When the value of the gum first attracted the attention of commerce recovery was a simple matter. The surface was freely littered with the nodules, ranging in size from small pebbles to pieces as large as a football, and of an endless variety of shapes. Then the gum could be obtained merely for the picking up, which was a fortunate circumstance considering the low price of £5 per ton which it commanded. However, as the market widened, and demand

became keener, the recovery of the product became more difficult. To-day the miners have to search, probe and dig for their treasure, and, as may be imagined, the venture is extremely speculative and often as heartbreaking in its results as the search for gold. Unhappily, in this phase of mining there is little to guide the prospector. The "signs," such as attend all metal mining enterprises, are conspicuous by their absence.

It is probably because of the extremely uncertain character of the work that organised mining has never been introduced. It is essentially a job for the individual or a small party working upon a collective or communal method. As a matter of fact it is regarded as being so precarious, and yet at the same time demanding such a small reserve of capital, as to become acknowledged as a job for the unemployed. New arrivals with more enthusiasm than money in their pockets, those who are down on their luck, and settlers during their off-season turn to gum-digging with a view to retrieving broken fortunes, securing the wherewithal to start operations in a more lucrative field, or to add to a meagre income. The natives also participate in the enterprise mainly to obtain further sinews of war to gratify a particular whim or fancy. In these circumstances there is no recognised stability in the industry, although as a rule there are plenty of labourers to work the "fields," but it is an ever fluctuating quantity. To-day the 800,000 acres may be the scenes of probing, digging and scratching by seven, eight or ten thousand men; to-morrow they will be roamed by a bare two thousand diligent toilers.

The diggers are like the gipsies. They roam hither and thither, the victims of mood and luck. Their methods are as varied as the men themselves. In its most primitive form

mining entails the use of a curious spear, from 10 to 12 feet in length, with which "blind fishing," as it may be called, is pursued. The miner searches for certain signs in the form of a decomposed stump, around which he prods the earth more or less diligently. If his spear should be thrust luckily, and alight upon a mass of gum, the latter will become impaled upon the hook and thus be brought to the surface.

It was this promiscuous and nomadic method of endeavouring to woo fortune which induced the Government to take the industry under its wing. The Kauri gum territory forms Crown Lands, and to exploit the wealth contained thereon it is necessary to obtain a mining licence, but as this only costs six shillings a year the outlay is not an insuperable obstacle. In return, however, the miner secures full protection as if he were toiling for gold, and is spared the danger of having his claim jumped or adjacent miners encroaching upon his property. This arrangement has led to certain organisations acquiring the right to exploit definite tracts which they allow to be mined by individuals, they purchasing the harvests.

Control of the land has brought about a certain improvement in the methods of mining, though the individual prospector armed with no more than a spear is still to be met frequently upon the "fields." Methods somewhat reminiscent to placer gold mining have been introduced. A section of land is staked, and this is excavated and examined thoroughly to a depth of twelve to fifteen feet, the earth being removed methodically by shovel.

The gum field bears a further resemblance to the conventional mining camp. The autocrat is the owner of the store. As a rule he finances operations, not in money, but in credit.

The gum-digger, upon arrival, is often penniless and foodless. But he cannot go out even to the gum field without a supply of provisions and other impedimenta, primitive though it may be. So he goes to the storekeeper, explains his intentions, receives advice, and if his face be honest and his proposals sound, he receives sufficient provisions to carry on, also being provided with facilities to reach his claim, the account being written against him upon the slate. At the end of the month there is a settlement. The digger's winnings are weighed up, and the value thereof set against his credit. Any balance in his favour, if such should be the case, is handed over to him, or, should he still be showing a deficiency and his determination to make good still be as keen, he receives another month's credit. The store is thus the digger's friend, guide and bank. The owner of the establishment is sometimes freely assailed for being exorbitant in his charges, but one must not forget that transport of provisions by road across country for a hundred or so miles is slow and costly. Occasionally, too, a miner decamps without squaring his account, and the loss thus entailed has to be spread over the other accounts which are owing, or rather the cost of provisions and equipment is increased to cover the deficiency, because the owner of the store does not bury himself in the gum country for the benefit of his health.

Monthly balancing of account is necessary because the miner is naturally a Romany, and he has 800,000 acres over which to wander. If his luck be out in one place he will hie to another and more promising tract. To these men the "lucky find" is always the lodestone and they flitter like butterflies over the field. Now and again luck will come their way in a most assertive manner. They will pick up enough

gum in a week to obtain £25 or so, but the blanks are generally more freely drawn than the prizes.

Reward in the main depends upon individual effort, and the life must be construed as hard and the hours long, with comfort a minus quantity. When the miner is working on his own his scale of living is the lowest. Naturally his one concern is to build up a healthy financial balance in his favour to enable him to quit the field as soon as possible, and so he will readily deny himself everything, subsisting on meagre fare and a shake-down for a few hours' sleep at night. He starts with the sun and does not throw down his tools until Old Sol has sunk well down into the western sky. Even then his day's work is not finished. The harvest, if any, must be got ready for market, and this is a job which may easily take from one to three hours according to the bag The gum has to be roughly scraped with a knife to remove the superfluous earth. When the pieces may be no larger than walnuts a gunny-sack full is likely to offer a tedious cleaning task, especially as it must be well and truly carried out, the buyer only being in the market for gum and not New Zealand freehold. After cleaning it is bagged and slipped into the miner's safe, otherwise under his bunk, to await the monthly settlement.

Although mining is prosecuted with more or less vigour and the contract arrangement with large organisations is coming into vogue, there are no signs of the fields becoming exhausted, although, of course, it is becoming more and more laborious to win the treasure from the necessity to resort to digging. It is believed that excavation might be continued to a far greater depth with success, though the cost of winning the gum would suffer an increase. Swamps are also being drained to contribute to the yield, while land which suffers

periodical water-logging is also being exploited during the dry season, although the grade of product recovered from such areas is inferior.

Synthesis, while having played a certain degree of havoc with the industry, enabling cheaper substitutes to be used widely, is not depreciating the value of the genuine article to any pronounced degree. The output is fairly regular, averaging from 8,000 to 9,000 tons a year, while the yields are generally promptly cleared, the United States of America being the largest purchaser, taking nearly 5,000 tons a year, while this country is the second-best customer. Nor is the rising prosperity of New Zealand and the golden opportunities it offers in every ramification of endeavour likely to affect the numerical strength of the ranks of the gum-diggers. The foreigner, especially he from Middle Europe where the standard of living is low, generally favour the fields for a time, although, until they have become naturalised the necessary licence costs £2. The work offers the chance to secure the requisite capital to mount the bottom rung of the ladder rising to bigger things.

Strange to say, however, there is an appreciable number of white men who find the fields, though dreary from the scenic point of view, exactly to their liking, the free, open life making irresistible appeal. These contented "magnates" of the industry have become inured to the peculiar conditions, have been able to establish a comfortable level of living, are highly skilled at their work, have amassed comfortable small fortunes, and so would not barter existence in the gum country for the most attractive positions in towns and cities. While such men frequent the gum fields there is very little likelihood of the industry decaying. Indeed, the tendency is in the opposite direction. The market is favourable and

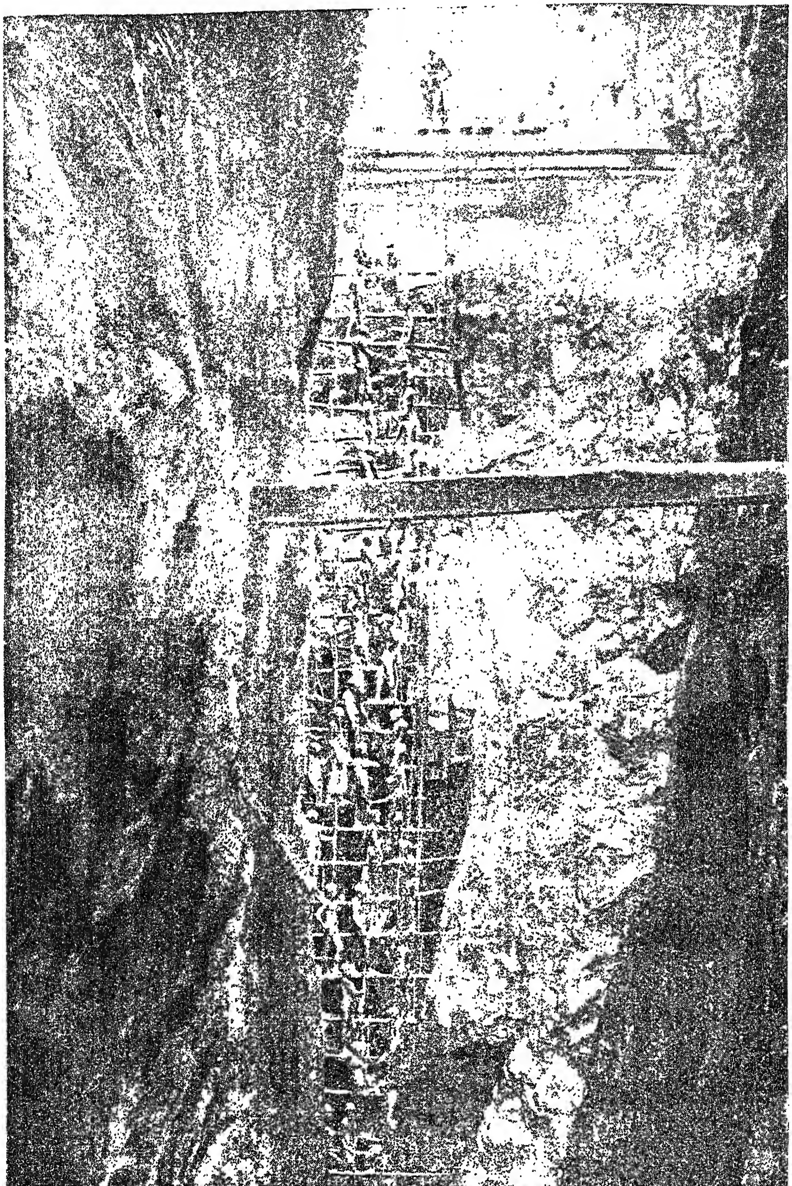
likely to rise, while decreasing labour is certain to send prices upward as supply diminishes, in accordance with the inexorable commercial law. The time may not be far distant when commercial exigencies will compel the introduction of more up-to-date and scientific methods, which will probably record the passing of a rugged and picturesque personality—the gum-digger of New Zealand.

CHAPTER XIII

Asbestos, Graphite, Mica and Talc

ONE of the strangest treasures won from the earth undoubtedly is asbestos. Doubtless there are many who may feel disposed to dispute the mineral origin of this substance, since in appearance, and to the uninitiated eye, it presents every appearance of having been made from a textile treated to a chemical dressing to render it fireproof. But asbestos is as much a mineral as coal or iron. The fibrous characteristic is peculiar to the substance. True, from time immemorial it has been worked into textiles, and has been submitted to many uses for which to-day flax and cotton are employed. It certainly is a curiosity of Nature in more ways than one, because it is probably the only mineral which can be passed through the textile machines and be woven into fabric, ropes and belts.

Nevertheless, it is one of the oldest commodities with which civilisation is familiar. It has been exploited since the days when the "world" was confined to an infinitesimal corner of Europe, the main sources of supply then being the Alps, Corsica, Cyprus, and subsequently Siberia. Yet, for centuries it was an industry which recorded no headway. It was the birth of the wonderful nineteenth century, the coming of steam, and the inauguration of the contemporary scientific and chemical era which induced this substance to be regarded in its true aspect—a non-conductor of heat.



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A PLUMBAGO MINE AT KURNEGALLE, CEYLON

Plumbago, or graphite, is a valuable mineral, and is the raw material used for the manufacture of lead pencils, as well as for a lubricant and many other purposes. The primitive ladder shown in the illustration presents a strange sight even in the romance of mining.

But the days when the above-mentioned centres of supply sufficed have long since passed. The mines which hundreds of years ago supplied all the asbestos which the world desired have fallen into decay. The centres of production, while still few in number, are wide apart. Canada furnishes the bulk of the world's requirements, although during recent years the apparent monopoly has been challenged by Russia, and more recently by South Africa. Even the industry has grown to huge proportions. It is estimated that to-day the capital invested in this quaint enterprise is approximately £25,000,000.

The asbestos mines of Canada are located at Thetford, in the province of Quebec, and here the treasure is torn from the earth in open quarries along the broad lines adopted in this country for the recovery of granite, slate and other commercial stones. The substance is a silky fibrous form of serpentine, to which the mineralogist has given the distinctive name chrysotile. That obtained from Griqualand, South Africa, is distinguished from the Canadian product as crocidolite, or blue asbestos, while the Russian is similar to that won from Quebec. In the last-named quarries or mines the material occurs in veins in the dark serpentine rock, and for the most part they are thin. The asbestos, however, is readily detected by its peculiar lustre, which stands out in vivid contrast to the rock in which it is embedded.

The pits extend over an extensive area and average about 200 feet in depth. They are spanned in all directions by aerial ropeways by which the material, as excavated, is carried to the treating plant. The veins are torn open and exposed by the usual quarrying methods, including free use of explosives. The mineral is sorted into three grades. The

best quality is found a little below the surface of the ground, while the lowest or most inferior grade is taken mostly from the bottom of the quarry. The surface specimens, as a rule, are indifferent, having suffered deterioration from several causes, the most destructive being forest fires, which evaporate the water from the fibres, rendering them coarse, hard and brittle. It is the presence of water which imparts the delicate silky texture to the substance. The veins are readily and easily reached, the imprisoning rock freely splitting and falling away to expose the vein. That won from the cliff faces is generally of the highest value, and it is this which is subjected to the various quondam textile operations, finally being carded and spun into thread. The second and third grades are submitted to somewhat different treatment, while the refuse is picked over by hand, whatever useful material it may contain thus being recovered.

The blue asbestos—crocidolite—is worked in a different manner. The field is somewhat extensive, prospecting and surveying having proved an area of 67,000 acres. It is situate in a very wild part of Griqualand, at an altitude of 3,000 feet above sea level, and 60 miles from the nearest railway point. Vegetation is scanty, while water is none too plentiful, periods of drought sometimes being experienced to add to the difficulties of mining. But the deposits are valuable, while the product in many respects and for certain applications is declared to be superior to the white asbestos obtained from Canada and Russia.

In Griqualand the mineral is won from underground workings, shafts having been sunk and tunnels and adits driven at varying levels to meet the shafts. The blue asbestos is very fibrous, of extreme silky lustre, and dull lavender blue in colour which is attributable to the quantity

of ferric oxide present, and which serves to differentiate it from the products hailing from Canada and Russia. The tensile strength is high, which, in conjunction with its other characteristics, renders it preferable to the competitive material for many specific applications. The mineral, as mined, is taken to a convenient point where it is cleaned and prepared for transport to the factory. After being shredded into fibres it is passed through the successive textile operations and finally turned into the material desired—woven fabric, rope, belting, cement slate, plastic composition—it is being used with increasing favour as an electrical insulating material—clothes, gloves and hats.

Another strange mineral with which we are all familiar, especially in these days of the talking machine, is mica. We speak of mica as if it were one individual substance such as gold, but as a matter of fact it comprises a rather large family, of which ten members enter into everyday use, so that the term mica is somewhat loose. The distinctive properties of the substance are transparency, glitter, and property of cleavage or splitting into very thin sheets or laminæ. It is being found in nearly every country, but its exploitation is not extensively practised owing to the precarious nature of the work, and the uncertainty regarding yield. Precisely when it was first utilised is obscure, but it certainly was in favour among the ancients, both in the utilitarian and artistic senses. Its transparency and flexibility rendered it an excellent glazing material for windows, while its glittering properties enabled it to be used in the powdered form to serve as a decorative agent for fête costumes. To this day it is extensively used in these two fields, more especially the last-named in connection with the embellishment of fancy dresses. In India, whence the

finest qualities are procured, much of the waste is used in this manner, the *tout ensemble* giving the glittering spangle effect which never fails to arrest attention.

To-day the utilitarian applications of mica are numerous. It is an excellent electrical insulator, and this forms its principal use, more particularly in connection with the preparation of condensers. It is also an excellent non-conductor of heat, and so we find it employed for the fabrication of chimneys and the protection of lenses in projection apparatus where intense heat is set up by the source of illumination, such as the electric arc. In India this heat non-conductivity is turned to account by using the waste for lining helmets, clothing, the hoods of vehicles, and so forth, as well as the insulation of refrigerators and ice chambers. It is also an excellent lubricant. It can be silvered and used as a mirror or reflector, the ability to bend it readily without breaking favouring this application. It can be employed as a base for photographic plates, and forms an excellent cover glass in the mounting of specimens for the microscope. To the lay mind its most obvious use, however, is in connection with the sound box of the talking machine, its elasticity rendering it particularly suitable for this purpose. It is sensitive to the slightest sound vibration, the diaphragm of mica thus being wonderfully responsive.

Although widely scattered throughout the various countries of the world commerce has become extremely discriminating in regard to this substance. The finest qualities are obtained from India, where the largest single sheet, measuring 10 feet high by 15 feet wide, was split from a block. Our Eastern Empire constitutes the principal centre of supply, Canada and the United States coming second. Unfortunately, however, it is a somewhat difficult mineral to handle.

It cannot be mined in the same way as the other commodities of commerce which are wrung from the earth. Its susceptibility to breakage and starring, coupled with its irregular distribution in the rock, render it difficult and somewhat expensive to excavate. It cannot be torn down by explosives, but must be removed carefully by hand. The recovery of the material in large sheets, of course, is the primary consideration, the larger the piece the higher the price obtained. This is one reason why mica mining has never attracted capital. In India the abundance of native labour which is cheap, combined with the high grade of the article obtained, makes its excavation highly profitable.

The mineral is usually found in pockets irregularly distributed throughout the rock. It is difficult to tell when and where the succeeding occurrence will be found. The rock must be broken down skilfully and in small pieces lest a remunerative deposit should be shattered in the process. In some places it is necessary to bring down a ton of rock to obtain but a few ounces of the mineral. Moreover, it is impossible to form any estimate as to the amount of mica a proved deposit is likely to carry; so it is always a matter for speculation as to whether it will pay to drive a tunnel, dig a pit, or excavate a gallery.

Then the proportion of waste runs somewhat high. In some mines only 2 per cent. of the mica mined possesses any commercial value, so much waste is incurred in the splitting and trimming. In Canada, according to experience which has been gained, only about 5 per cent. of the material mined will yield sheets measuring 8 inches long by 5 inches wide, while much only runs to 3 by 2 inches. Even this, however, is able to command about 1s. 6d. per pound under normal trading conditions. The general practice in the

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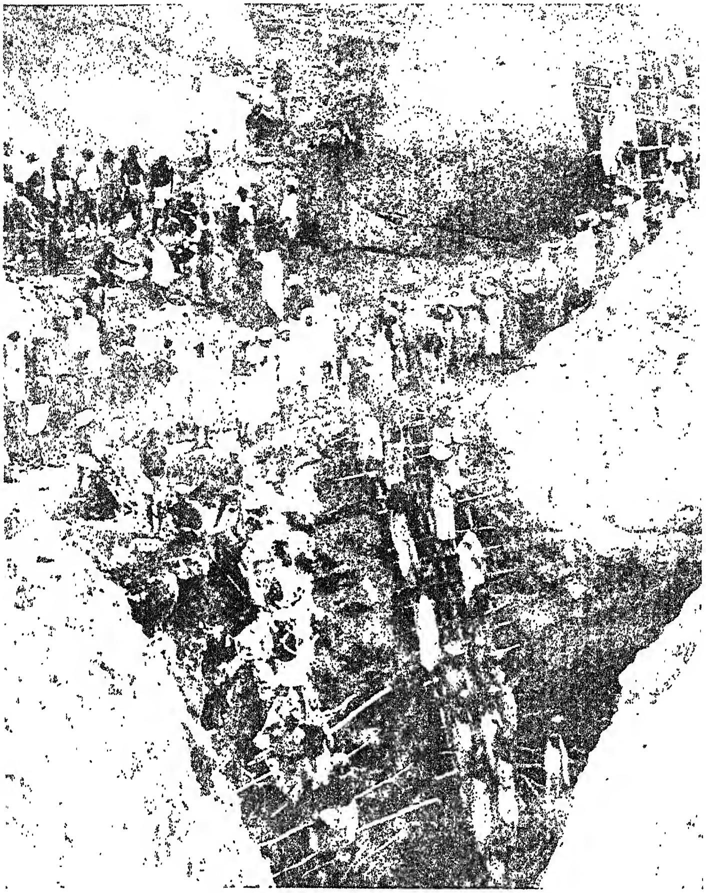
Canadian mines, where blasting is practised, is to excavate the block of mica which is discovered, and, if it should be deemed satisfactory, to split it into laminæ. These sheets are then cleaned and sorted, and, at the final mica cutting works, are given a last dressing. Although heavy waste is incurred in preparing the sheets for the market, endeavours to turn this refuse to account have been carried out diligently during the past few years, and have resulted in the perfection of processes which enable a certain quantity of the residue to be used in the preparation of other products. It is combined with an efficient cement to form compressed blocks, or is reduced to powder.

In India mica mining is conducted along totally different lines which, in comparison, may seem distinctly primitive. The most valuable grade is derived from the Hazaribagh district. The deposits for the most part are found in the jungle, and the mining, if such it may be termed, is carried out by coolies. As a rule the mica rests near the surface, and so the native workers scoop away the surface soil to lay bare the irregular mass which can then be removed with comparative ease. As a rule the chunks do not exceed 14 inches in length by 6 inches in thickness. When recovered the mica is split into sheets, trimmed if necessary, and then graded according to size and quality, the packages, as prepared for transport, being known as books. If the sheets run to a large size their value is considerably enhanced, and, as may be imagined, the search for large blocks is prosecuted with avidity, owing to the encouraging reward it brings. Thus a single sheet measuring 30 inches square would probably be worth approximately £10. The natives have come to learn the value of these large sheets, and are aware of the keenness with which independent buyers will compete for



MICA MINING IN INDIA

The search for "natural glass" is an important industry in our Eastern Empire whence the finest grades of mica are obtained. It is found in masses, irregularly distributed, which are subsequently cut, trimmed and split into thin sheets. Mining is conducted along somewhat primitive lines, being somewhat precarious, but is profitable because the mineral is indispensable to modern science and industry.

them. As a result a form of illicit trading has developed, the lucky finder experiencing no difficulty in disposing surreptitiously of his strike through an intermediary who is in close touch with the unscrupulous purchasing market.

Another substance more or less allied to mica, but differing very markedly therefrom in its essential characteristics, is talc, especially the variety known as steatite or soapstone. This is often described as powdered mica, but that is erroneous, because there is a striking difference between the two materials when reduced to the pulverised condition. The mica dust is sharp to the touch, somewhat reminiscent of powdered glass, but pulverised talc has a velvet-like feeling. It is this greasy property which has led to its widespread utilisation for the preparation of cosmetics and other toilet specialities.

It is a mineral composed almost entirely of silica, magnesia and water. In the crude form it is light in colour, lustrous, and has a foliated or fibrous structure. It is extremely soft and flexible, has low conductivity and is capable of absorbing heat and electricity to a high degree. It is mined after the manner of so many other minerals and then ground and prepared for the market. The principal centre of production and consumption is the United States of America. There are vast deposits in the country, but, although producing more than all the other countries in the world combined—about 150,000 tons a year—it is also a purchaser, especially of finer grades than can be obtained at home, notably those derived in France, the product in this instance being known as French chalk. However, as a result of trading custom the term French chalk to-day is employed in commercial circles in the broadest sense, and implies talc of all descriptions, irrespective of country of

origin, although in reality it should apply distinctively to the French article, which excels all others in quality.

The talc mining industry is developing rapidly inasmuch as further fields of application are being discovered for the material. In some directions it is displacing other materials which have held sway for many years. Among the many uses to which it is put may be mentioned the manufacture of paper in the capacity of a filler, more especially book and writing papers. In this connection it is displacing china clay to an increasing degree. It not only increases the weight of the paper, but improves its whiteness, opacity and absorption qualities. Paper so treated will also take a high polish. It enters into the manufacture of insulator coverings, paints, the dressing of skins and leather, is employed for the sizing and bleaching of cotton cloth—we know it as "dressing"—glazing, the manufacture of porcelain, and for dusting the insides of boots, shoes and gloves to facilitate trying on. It enters into the fabrication of tailors' chalk, tips of gas burners and pencils, while the French and Italian varieties, owing to their pronounced grease absorbing qualities, constitute an excellent base in the preparation of rouge.

While the United States ranks as the world's principal producer and supplies the greater part of the needs of the other countries, South Africa promises to become a formidable competitor. Exceedingly rich deposits have been found in Rhodesia mainly through the perseverance and diligence of one prospector who has devoted his efforts for the past eight or nine years to the discovery of this treasure. Prospecting for talc does not sound very exciting, nor is the reward so overwhelmingly bounteous as that attending the discovery of a new diamond or gold field, but talc is indispensable to industry, and already the patience of the pro-

spector is receiving adequate compensation. A demand for South African talc has set in, and it is a range of endeavour capable of indefinite expansion, so that the possibility of the ridiculed soil-scratcher for talc becoming a millionaire is not so remote as at one time appeared to be the case.

Graphite, or plumbago, is another mineral possessing unguent properties. Although it is a solid, and accordingly has a certain vogue as a lubricant, it is more valuable to the metal trades. This substance is widely distributed throughout the world, but it varies very widely in quality. Up to the present Ceylon has been found to yield the finest grade of graphite, which is in world-wide demand. It is practically pure carbon, and its most successful application is in connection with crucibles, which constitute an indispensable adjunct to those trades employing intense heat, such as the metallurgical industries. The output from the island lying off the south-eastern corner of our Indian Empire averages about 50,000 tons per annum, and the principal buyers are Britain and the United States of America.

During recent years it has been found possible to produce graphite synthetically in the electric furnace, and it was thought that the article thus produced would oust the product from Nature's furnace from the market. But, curiously enough, the demand for Ceylon graphite was never so great as it is to-day; man with all his wonderful scientific appliances and knowledge has not yet succeeded in producing an article excelling that evolved by Nature in this particular field.

The graphite mine is somewhat curious. An open shaft is sunk through the rock carrying the mineral in streaks, nests and pockets. It occurs frequently in a fibrous or flaky form, the flakes being at right angles to the wall of the vein.

The richness of the latter fluctuates widely. It may be only a fraction of an inch in thickness; on the other hand, it may be several feet in width. A number of pits are sunk closely side by side so that one large vein may possibly be traversed by half a dozen or more shafts, from which smaller streaks of paying mineral radiate in all directions.

Mining operations are almost exclusively conducted by the natives and, as may be imagined, are carried out along somewhat primitive lines. Prospecting such as the white man knows the term is rarely carried out. A native walking through the forest kicks his foot against an outcrop of graphite. It may be a pocket, thin streak, or a thick vein. The finder does not waste time in probing the earth to find if any other deposits are there, or whether this outcrop happens to be merely an isolated appearance. He immediately commences to dig a pit, removing the mineral as he descends, and continuing his task until the deposit gives out, when the pit is abandoned.

In the richer and proved areas working proceeds along slightly more organised lines. The shaft is not a shaft as we know it; it is rather a rude fissure between the rocks, the line of least resistance being followed. At the top a more or less substantial staging is erected from materials found upon the spot, and from this depends a native ladder, formed of lengths of bamboo six or more feet which serve as the rungs, held together by coir or native rope wrought from such flexible materials as the jungle will provide. It is rather an ungainly rope ladder, of decidedly clumsy appearance, and certainly possesses but an insignificant degree of safety. This ladder is set at a slight angle to the vertical merely by wedging the bamboo cross-pieces at intervals against the side walls of the pit. Thus the ladder resembles a very

steeply set flight of steps. The rungs are placed rather widely apart, and no little agility is required to climb from one to the other, but the natives move up and down with astonishing celerity. The "steps" being wide, it is possible for three or four streams of humanity to pass up and down simultaneously, side by side, on the one ladder. The mineral is brought to the surface in baskets, and the constant passing to and fro has imparted a rich sheen and slippery surface to the rungs, rendering them practically impassable by aught but the lithe and nimble native miners.

The tools employed for the excavation of the mineral are comparable to the ladder in crudity. The graphite is dumped into barrel-shaped baskets which are slung on the shoulders of the miners. The graphite mine presents a strange and picturesque activity. The streams of humanity are moving endlessly up and down, the climbers with their loads, and the others returning with the empty baskets for fresh charges. The bodies of one and all have become coated with the mineral, and under the constant movement become brightly polished, imparting an appearance in the brilliant sunlight of animated figures wrought in shining steel.

Now and again a pit is flooded, but the natives do not worry. They have evolved their own means of coping with this fiend. A V-channel, fashioned from lengths of wood, is made. The sections are lashed together to form a continuous conduit. This is led from the level in which flooding has occurred to a point where the water may be discharged safely. At certain mines, notably where the deposits are unusually rich, an attempt to convert native ingenuity to mechanical modernity has been made, but it is not very pronounced, being confined for the most part to the utilisation of steam power for the removal of the water, and the employ-

ment of hoists for hauling the mineral to the surface. The graphite is passed through various cleaning processes, all manually conducted by native labour, to remove impurities. Although the method may appear to be imperfect, the resultant product is really of very high quality, the women and children having acquired uncanny dexterity in this phase of the work.

Plumbago mining is controlled by the Government. Mining on Crown Lands requires a licence, but the natives, especially during periods of boom, are not loath to practise illicit tactics, and will even resort to poaching should the opportunity develop. The industry is almost entirely in the hands of the natives, upwards of 30,000 men, women and children finding occupation in the production of a mineral worth more than £1,000,000 a year. Labour is cheap and plentiful, but the market is firm, and although the Government exacts a toll in the form of export duty upon every ton dispatched to foreign markets, handsome profits are made. Some of the more progressive and thrifty natives have amassed comfortable fortunes from mining plumbago. The capital outlay involved is insignificant, and there is a handsome margin of profit. Other industries have suffered from the perfection of synthetic chemico-mechanical and electro-metallurgical processes, but the Ceylon graphite mining industry is one of the few which have benefited from the competition offered by artificial production, for the simple reason that the article thus obtained is superior to that made in the factory.

CHAPTER XIV

The Rarer Metals

THE term "rarer metals" may appear to be somewhat ambiguous. From the strictly technical point of view the metals are held to embrace those which have only been discovered in the laboratory, and thus, while known to science, are not commercially exploited upon an elaborate scale, as well as others which are only secured with extreme difficulty. What may legitimately be entitled to the classification of "rare" to-day may become commonplace, or at least readily accessible, to-morrow. The true commercial interpretation of the expression "rare" therefore may be accepted rather in its literal sense, namely, that such minerals are rare for the simple reason that the known deposits are exceedingly restricted, and that consequently supply is far and away below demand.

It was not many years ago that the mineral osmium was accepted merely as a known constituent of the earth's crust. Its discovery was accepted rather as a triumph for science, inasmuch as it filled another gap in the Periodic Law. Its possible commercial applications were purely speculative. Then came the discovery of the metallic-filament incandescent electric lamp and the proved adaptability of osmium for this peculiar purpose. Instantly a demand for the mineral set in. A metal which, while known for over a century, had always been regarded with disgust by prospectors and de-

clared an unmitigated nuisance by mining engineers, became invested with striking commercial value, and the enterprising countries of the world immediately extended all encouragement to prospectors, apprising them in concise, simple language, of the characteristics of the metal and information as to where it might be found, at the same time enjoining them to keep a sharp eye open for all occurrences thereof.

It was the same with platinum. This metal had been known for more years than one is able to remember, but its commercial value was virtually nil. It was used to a certain degree in the arts, especially in connection with the fabrication of jewellery and other articles of personal adornment, although even in this field its employment was extremely limited because its artistic value failed to find favour. The Russian authorities endeavoured to popularise the commercial exploitation of the metal, which was natural, seeing that it was to be found readily and in paying quantities in that country. The Muscovite Government even went so far as to issue a platinum coinage, but it failed to meet with approval, although during recent years there has been a keen search for these coins, merely to melt them down.

As a commercial metal for distinctive applications platinum has no equal. Its uses to-day, in the strict utilitarian sense, are manifold. Probably one of the most extensive fields of employment is in connection with the manufacture of false teeth, this being the only metal which is able to offer a complete resistance to the acids forming the saliva. The teeth are set upon platinum points, thus securing them to their foundation or base. Again, platinum came into demand, upon the introduction of the motor-car, for the contact breakers and magnetos of the ignition systems. Attempts to substitute it by German silver in this field have been made,

but the effort is a sorry one. These are only two, and the most popularly familiar, fields of application, but there are scores of others which might be cited.

Pure platinum is a silvery white metal almost as hard as iron and just as malleable. It is the second heaviest element known, pride of place in this connection being occupied by its ally, iridium. If one were handed a cube of platinum measuring twelve inches each way—a solid cubic foot—one would drop it hurriedly, since it would weigh no less than 1,270 pounds, or more than half a ton. To realise the true significance of this weight it is only necessary to compare it with a similar cubic foot of some other more familiar substance, such as coal, which might readily be carried on the shoulder, the weight thereof being only about 80 pounds.

Platinum has many distinctive characteristics. It resolutely refuses to make friends with quicksilver or cyanide of potassium, in which it differs markedly from gold. It even sternly resists the attacks of acids, with the exception of that powerful combination of nitric and hydrochloric acids colloquially known as *aqua regia*. If one be panning sand where platinum is present it cannot be mistaken. One may rotate the pan with sufficient violence even to send the gold scurrying away, though that is not an easy matter, but if platinum be present it will settle to the bottom, since it is heavier than the yellow metal. Accordingly, if one be sluicing for gold, and platinum should be present, one may confidently rely upon trapping the platinum as well as the gold. Furthermore, as gold is readily detected from its yellow colour, so is platinum recognised from its white sheen, which is brighter than that of lead. But, at the same time, despite these outstanding characteristics, it is somewhat elusive. In

As a rule, shaft-sinking and tunnelling, as well as the excavation of the ore, are carried out in the winter, when the conditions render surface working impossible, the pay-dirt being dumped for treatment the following summer. The platinum-bearing gravel is loaded into half-ton wagons, and hauled up an incline to the washing plant. Here it is discharged upon screens or trommels with water, that which passes through the meshes being led to the sluice boxes, where the platinum settles out. The waste from the sluice boxes is passed through and over the further plant which arrests the heavier sand, and, as this is likely to be associated with traces of platinum, the tailings are panned by hand to recover any remaining metal. With this simple type of washing plant about 125 tons of pay-sand can be handled every eight hours, the platinum yield varying from 24 to 480 grains per cubic yard.

In order to treat the pay-dirt along more efficient and quicker lines dredging plant has been introduced. The dredger resembles in the essential details that employed for the recovery of gold, but the early work conducted along these lines did not prove completely successful. The outstanding advantage, however, is the greater quantity of pay-dirt which can be handled during the day. Although the dredging system has met with a certain degree of appreciation, it is not likely to displace the older system, which is held to be more positive in its action.

During the past few years the attractive price of platinum, and the increasing commercial demand which has arisen therefor, have been responsible for the opening up of other promising districts in various parts of the world. This is particularly marked in the United States and South America, especially the latter district, where the conditions admit of

dredging being followed upon an extensive scale. Owing to the wealth of other minerals in Australia the possible occurrence of platinum has provoked intensified interest in location of deposits, and a certain measure of success has been achieved. Beach sands in the northern coastal district have been found to yield the valuable metal, while at Broken Hill platinum-bearing ore has been located. At the moment, the centre of Australian production is Platina, where gold is found in association with the platinum; but the Australian contribution to the world's requirements so far has not been pronounced, being less than 14,000 ounces all told—less than a single year's import into this country.

Now that osmium is in demand for the fabrication of incandescent electric lamp filaments this metal is receiving closer attention. Tasmania has come into prominence in connection with it. A deposit of osmiridium was found some years ago in the bed of Savage River on the West Coast, while traces were observed in certain creeks. But these beds were neglected until 1911, when a small army of 100 men devoted their energies towards the recovery of this treasure, attracted by the ruling price, £7 10s. an ounce. As a result of this diligent search 272 ounces were secured and sold for £1,888. The price rose to as high a figure as £11 per ounce, which was certainly abnormal, seeing that during 1914 an American purchaser bought 13 ounces at an average price of £5 16s. 6d. per ounce. Some excitement was created by a prospector picking up a small nugget of the mineral, which is very rarely found except in dust form, the "find" weighing 1,152 grains.

Iridium, as already mentioned, is the heaviest metal known, the weight of a single cubic foot when hammered being 1,930 pounds, or nearly one ton. It is a hard-wearing

metal, and its commercial utilisation is almost exclusively confined to the manufacture of fountain-pens, the nibs of which are tipped therewith. A certain proportion, both of osmium and iridium, is used in the manufacture of hard platinum jewellery, the demand in connection with which is increasing somewhat strikingly, Dame Fashion having discovered the beauties of these metals for purposes of personal embellishment.

Another metal which was brought prominently to the commercial and industrial forefront as a result of the development of the metallic filament electric lamp was tantalum, derived from the ore tantalite. Here again Australia proved a surprise, prospecting revealing a fairly extensive lode in the Wodgina tinfield. But the call for tantalum was very promptly satisfied, only a very minute quantity being required to furnish the spider-like thread inserted in the incandescent bulb. Consequently a pound of the metal will go a very long way. Production upon the Australian field outstripped demand, the yield obtained from Western Australia being 73 tons, which was worth £10,000. Further mining was arrested until the reserves upon the market had been absorbed. Since 1919 the industry has been in a sorry plight, there being practically no market for this mineral to-day. This result, no doubt, is due to the supersession of the tantalum lamp by others of the metallic filament order, the minerals used in connection with which have been found to be superior to that derived from tantalite.

The search for rare metals during the past few years has been stimulated by the extraordinary advances in the metallurgy of steel. It has been found that by adding small quantities of certain rare metals to steel specific properties not otherwise obtainable are imparted to the product. Thus

the addition of vanadium enables the finest steel to be twisted and bent into the most fantastic shapes without breaking. Tungsten imparts wonderful strength, as does also molybdenum and chromium, while there has also been a remarkable development in the production of manganese steel. Each successive discovery by the metallurgical chemist adds zest to the mining industry, more particularly when it involves the supply of a mineral which is scarcely known, deposits of which are mythical, and supplies of which are likely to be meagre for an appreciable time. In such circumstances prices must necessarily rule high. Accordingly, the prospector keeps a sharp eye upon developments in the manufacture of steel.

Tungsten, literally heavy-stone, was discovered over a century and a quarter ago, but it is only within the past few years that its value has really been recognised. Its hardness and ductility are extraordinary. In the pure state it can be drawn out into spider's threads $\frac{1}{1000}$ inch in thickness, while it has to be raised to a very high temperature before it will melt. It is an absolutely indispensable constituent of high-speed steel for the fashioning of steel-working tools, and also of magnet steel, while it is also used in the manufacture of metallic filaments for electric incandescent lamps and X-ray tubes.

When it was learned that the steel making industries of the world were clamouring for tungsten the search for the two ores whence it is principally obtained, namely wolfram and scheelite respectively, was pursued with extraordinary vigour. The preparation of the product for the market involves an elaborate process, but that is a secondary consideration. The raw material was the crux to the whole problem. All countries throughout the world turned over

their known mineral possessions to see if there were any wolfram or scheelite among them. Those countries which were able to point to tin mining activity were in the most fortunate position, because wolfram is generally found in close residence to tin.

Again it was Australia which produced a surprise by the discovery of a big deposit in Queensland, which was promptly christened Wolfram Camp, and is probably the most prolific and consistent producer of this ore to-day. In 1903 the output of wolfram was valued at £7,870, and these supplies were recovered in the main as a by-product from the winning of tin. Then mining for wolfram for its own intrinsic worth was taken in hand. In 1904, a year later, the contribution from the Australian State jumped to £161,735!

Wolfram Camp in reality covers an extensive area, and the mineral is won both from the reef and alluvium. The last-named was found to be particularly rich, the miners, after stripping off the useless overburden, being able to secure wash-dirt yielding as much as a bag of wolfram from every cubic yard. Immediately upon this discovery a tunnel was driven into the hillside to traverse ten distinct reefs, where almost pure mineral was found, the streaks ranging from 10 to 70 inches in thickness. Being so abundant and in such a pure condition, the miners found it profitable to resort to the most primitive of methods to win the ore. All they did was to roast the quartz in wood fires, subsequently breaking up the material to permit concentration by ordinary sluicing and kindred crude processes. At other points in the field, however, more scientific methods were introduced from the very beginning, so as to place the industry upon a firm and solid basis. During the year 1915 Queensland

produced £54,300 worth of wolfram out of a total of £76,667 standing to the credit of this mineral for the whole Commonwealth, while the total value of the wolfram produced by the State from the time it was first discovered up to the end of 1915 amounted to £964,638.

But the war imposed a demand for tungsten which it was quite impossible to meet. Accordingly search was made for its close ally to meet the emergency. The ally in question is molybdenum, which is capable, when reduced to the non-ferrous alloy, as is the case with tungsten, of fulfilling the same purpose as the last named. Fortunately molybdenite, the ore in question, is more freely distributed than wolfram, and this circumstance led to activity in fields where, owing to the absence of tungsten ore, but little interest had been evinced. This was notably the case in Ontario, in which Canadian province there was considerable prospecting for this mineral. The quest is rendered somewhat exasperating from the circumstance that the occurrences are likely to be in the form of pockets and irregular in form, but occasionally it is possible to alight upon a rich deposit and to resort to orthodox mining practice. This proved to be the case in this instance, a mine devoted to the winning of this mineral being developed at Quyon, in the province of Quebec, while another highly promising extensive deposit was opened up in Ontario. During 1917 this province yielded 77,517 pounds of the mineral, while at the two plants in the province—ferro-molybdenum is prepared in the electric furnace—150,000 pounds of molybdenum, valued at £69,871, were produced.

Another little-known mineral which has been forced to the front from the demands of the steel maker is chromium. This is likewise employed for the manufacture of tool steel,

as well as armour-plate and guns. This valuable constituent is obtained from various parts of the world, the largest producer outside the British Empire being New Caledonia, which furnished more than 74,000 tons in 1916. So far as the Empire itself is concerned, there is no need for anxiety, because during the self-same year Rhodesia supplied nearly 89,000 tons, and thus ranks as the largest chromium producing country in the world. The province of Quebec was the largest Canadian producer, giving 35,726 tons, worth nearly £100,000. in 1917. The price, notwithstanding the fairly high world-wide yield, is attractive, though naturally it varies according to the richness of the ore, but the market gives every indication of going still higher.

Other lesser known minerals which have come into commercial recognition during recent years might be mentioned. There is barite (or barytes), a heavy white mineral veining limestones and sandstones, as well as being combined with lead and other ores. It is useful for the manufacture of paints, especially the "flat" wall paints which now are so much the vogue, in the indiarubber manufacturing trade, and in the preparation of chemicals for various uses, such as the purification of salt, making of fireworks, and to baser use as an adulterant of white lead. Lithium—the lightest metal known, a cubic foot weighing but 59 pounds—a soft white metal, enters into the pharmacopœia; selenium, a long neglected metal, is now being utilised to convert light into sound, as in the optophone, to enable the blind to read; as well as many others familiar in name only, or for which no known or only limited commercial uses have yet been found, such as beryllium, zirconia, titanium and strontium, to mention only a few. Many are reduced to the metallic

form with infinite difficulty, and are exceedingly expensive, beryllium, for instance, costing £50 an ounce.

The moment commerce finds a use for any of these so-called rare metals production will commence in grim earnest. The difficulties which at present prevail will be subjugated, rendering the metals as cheap as dirt, to quote a colloquialism. It was not many years ago that aluminium was worth £800 a ton—if you could obtain such a quantity. Again, before the introduction of the electric furnace, silicon was worth £20 an ounce, despite the fact that silica is the most abundant material in the whole scheme of Nature. To-day it is not worth a penny an ounce. The prospector and treasure-seeker are certainly exposed to many and violent ups and downs in the financial as well as the physical sense.

CHAPTER XV

The Rarest Mineral in the World

IN 1902 a wave of extraordinary excitement rolled round the world. The most hardened and weather-beaten seekers for gold and other treasures of the earth rubbed their eyes with amazement. Had they, in their blind, frenzied rush for the yellow and other highly prized metals, been permitting wealth untold to slip through their fingers unconsciously? It certainly seemed like it. In comparison with the value of the new treasure present in the earth the biggest gold nugget and largest diamond, even the huge wonderful Cullinan, appeared to be as pebbles. The value of the new mineral was astonishing; it was variously set down at being worth anything between £6,000 and £10,000 per grain, that is, the $\frac{1}{480}$th part of an ounce. The price was so high as to appear incredible. Surely there was no mineral of such vast intrinsic worth to be found on this sphere.

The excitement, however, which the recital of startling figures aroused was promptly quenched. The treasure-seeker, half prompted to cast all other prizes aside, learned that though the reward was high it was futile to scratch the earth for the mineral, for the simple reason that it does not exist, at least so far as is known, in the pure or native state. Its recovery is a problem, not for the prospector and miner, but for the chemist, and as events have proved, the

process involved is about as complicated and as tedious as one could possibly conceive. So the prospector breathed freely once more. He would still confine his energies to the discovery of those prizes the value of which might be trifling in comparison, but the recovery of which, though fickle, was more probable.

The mineral in question was radium, discovered after a long, patient and systematic search conducted by Madame Curie and her consort. It was a new element, and it was the extraordinary and novel radio-active properties with which it was invested which was responsible for the sensation which attended its presentation to the world. Its determination added another contribution to the Periodic Law, and so the discovery ranked rather as a monumental scientific achievement than a triumph for commerce, because radium is so elusive as to defy all attempts to isolate it. That is to say, radium has not yet been obtained in a pure form comparable with gold, although Madame Curie has produced an infinitesimal quantity—a mere speck—in her laboratory. Accordingly its precise nature is still somewhat obscure. It is recovered in the form of compounds, the best known of which are radium bromide and radium chloride.

Yet the discovery was of far-reaching import in the commercial sense. Its distribution was described to be somewhat wide, although to be found only in minute quantities and associated with a diversity of other substances. It is also present in certain springs and gases exuding from the earth. This was not all. According to the information given to the world by the French chemists who had tracked it down, it was evident that there were piles of rubbish disfiguring the countryside in the vicinity of certain mines which had been considered as utterly worthless, but which it would pay

commerce to re-investigate, because they probably contained wealth untold. It was only necessary to harness science to the chariot of industry and to pass these artificial straggling hills through an intricate and special mill designed by the chemists. It was even suggested that just to win this new and precious product it might pay to reopen certain mines which had been abandoned as unable to contribute any minerals of consequence to commerce, or which had fallen into a condition of commercial coma through proving unprofitable.

Such a mine was that of Joachimsthal, in Bohemia. This burrow into the crust of the earth was made some six hundred years ago to exploit the silver which was said to abound. When the lode was opened up it was found to be exceedingly rich. Hundreds of miners found employment, and for years it ranked as one of the most important mines in Europe. But Joachimsthal was destined to share the fate of all mines. Mineral lodes are not like the widow's cruse of oil. They are generally of limited content, although the dimensions of the veins naturally vary very widely. But sooner or later the mineral streaks become attenuated and less and less profitable to work, with the result that they have to be abandoned. The Bohemian mine was no exception to the inevitable rule. Its lodes grew thinner and thinner, and it is quite probable that the workings would have been permitted to fall into decay, even if they had not suffered complete abandonment, but for one fortunate circumstance. Certainly the mine was confronted with the prospect of being shut down, and as its activity dwindled and dwindled with the passing of the years the miners departed to more attractive pastures, until only a handful remained to eke out a more or less precarious existence. As a commercial under-

taking Joachimsthal promised to become naught but a mere memory.

At the very moment when its fate appeared to be sealed the chemist happened to discover that this mine was rich in another ore—pitchblende—which was of marked purity. Now pitchblende is the ore from which uranium is obtained. Uranium in the pure state is useless, except as a scientific curiosity. So far commerce has failed to find a use for it. In a compound form, however, namely, uranium salts, it is in increasing request, entering prominently into the photographic, glass and porcelain industries. The price, too, was certainly attractive, the salts being able to command 2s. and more per ounce. Accordingly it was decided to continue the working of the quondam silver mine, though upon a reduced scale, for its uranium content.

Then came the announcement of the discovery of radium, together with the information that this extremely valuable product was obtained by the disintegration of uranium, which was recovered from pitchblende. Forthwith the ore from the erstwhile silver mine was subjected to another searching examination by the chemist, and was found to yield this new element. As a matter of fact it was from the Joachimsthal ore that Madame Curie succeeded in isolating the radio-active substance which caused such a commotion in scientific circles.

It is not surprising that the Joachimsthal mine became invested with an indefinable importance. As far as was known, no other mine was able to contribute pitchblende of such purity. Joachimsthal was consequently virtually the only radium mine in the world. Realising the opportunity, the Austrian Government decided to profit from the situation. The mine was turned into a national undertaking,

while radium was converted into an Austrian monopoly. This was far more powerful than might be imagined, because Austria was in the position of being able to fix the world's price for this product. The official move was astute, because, although the Government mine yielded a first-class pitchblende, the seat of greatest activity was two private mines which, under the edict, were compelled to sell their yields to the authorities.

The radium mine in Austria was sunk at least six hundred years ago, and the pitchblende is found in isolated lumps in streaks of mica schist found in masses in the granite. The veins vary considerably in character and richness, some being only a few inches in width, while others are about 12 feet in diameter. The masses of pitchblende for the most part are of convenient size, and in some instances run up to several pounds in weight. They are picked over by hand and submitted to a rough cleaning. Then they are passed into a somewhat primitive mill, which crushes the ore to powder to facilitate the recovery of the uranium in the form of oxide. After treatment the percentage of uranium oxide, which in the crude ore may not exceed 4 per cent., is about 50 per cent. The ore is sold to the Government, and is then transferred to the official uranium factory, which is really the old silver smelter erected for the treatment of the original metal product from the mines, and is subsequently passed into the radium factory, which was erected a few years ago.

Although the commercial uses for radium are severely restricted, yet it was in keen demand by hospitals throughout the world, having been found eminently useful for certain therapeutical purposes. Dependence upon the Austrian source of supply, however, was regarded as a distinct handicap, inasmuch as the hospitals were compelled to pay the

price which the monopoly demanded, and the quotation was purely artificial. Furthermore, the output was extremely low. In 1906 only 32,000 pounds of ore were mined, the value of the radium bromide obtained from which was about £10,000.

To secure independence of the Austrian monopoly other likely sources of supply in various parts of the world were investigated. The centre which was subjected to the most critical examination was Cornwall, and it was the refuse dumps from the tin mines which attracted attention. This refuse was found to be rich in pitchblende containing uranium. The richest dump was found straggling around the mouth of the Wheal Trendwith mine at St. Ives—one which had long since been abandoned. When this mine was worked for its tin the miners were harassed by the quantity of pitchblende which they encountered. At first, impressed with its quantity, they carefully collected the ore and set it on one side, thinking that it carried copper in attractive proportions. When subsequent smelting revealed only an inferior metal, and in minute quantities, the accumulation was thrown to one side in disgust, especially as an analyst of those days, when the value of pitchblende was not appreciated, confirmed the statement that the ore was nothing but rubbish. So it was dumped with the other useless spoil. Furthermore, it so hampered tin mining as to be construed into an incubus, and brought about the subsequent abandonment of the mine. Subsequently, when the world commenced to display a hunger for pitchblende, these rubbish heaps were overhauled and the spurned ore subjected to a further analysis. It was then found to be rich in the essential uranium salts whence the radium is obtained. Consequently it was decided to re-exploit the

dumps and also to resume working the abandoned mine, especially as other processes had been perfected, enabling other minerals to be won from the ore, a market for which had arisen.

Unfortunately at that time there were no facilities in Britain for extracting the radium from the uranium. Forthwith a factory was established in Germany to treat this Cornish pitchblende, while at a later date another similar institution was established in Paris. The whole of the Cornish uranium ores were exported to the Continent, and it was not long before Cornwall became a severe competitor with the Austrian Government mine, this competition effectively destroying its monopoly. The output from the Joachimsthal mine was speedily eclipsed by that from Cornwall, the result being that the world now became virtually dependent upon what could be secured from British sources.

The Austrian Government retaliated to this latest development by prohibiting the export of any ore from the country, doubtless hoping that the Cornish supply would prove unsuitable or unprofitable, in which event it would be able to wield a more powerful world-wide sway than ever. If these were the hopes entertained they were doomed to disappointment. The Cornish ore proved to be superior to that derived from the Joachimsthal mine, and the trade in its preparation developed speedily. This is borne out by the fact that during 1907 the rubbish heaps of the Duchy mine yielded 71 tons of uranium oxide, which was far and away in excess of the output of the Austrian mine. Seeing that it requires about 10 tons of the essential raw material to furnish only a few milligrams—one or two grains—of radium, some idea of the elaborate character of the recovery process may be obtained. Again, Cornwall prof-

fered this advantage. Whereas in Austria it was necessary to descend into the earth and to mine for the pitchblende as if it were the ore of another mineral, in the British county work was resolved to turning over the muck-heap at the head of the mine and in the open air, cost of recovery thus being reduced to the minimum. So the monopolistic Central European centre of supply was hopelessly beaten from every point of view.

As the months passed and the demand for radium increased, especially in Britain, the hospitals of which were experiencing difficulty in obtaining supplies, it was regarded as being somewhat derogatory to domestic industry to ship the valuable raw material abroad and to depend upon foreign reducing factories for our own needs. It was decided to establish a similar factory in this country. In this way the British Radium Institute was founded, and it was placed upon a far more attractive foundation and confronted with a far more favourable future than its continental rivals, inasmuch as there were all the contributory resources of Cornwall at its command. More than this was to be recorded. The reopening of the Wheal Trendwith mine, as well as the closer investigation of the ores derived from other mines in the St. Ives district, pointed to the existence of practically inexhaustible supplies of the necessary ore. It was obvious that, under the conditions obtaining, it would be possible to reduce the expense of concentration to a very pronounced degree, the result being that the Central European monopoly was now completely crushed. To-day the spoil from the mines which only a few years ago might have been obtained for the mere asking, and which one might have carted away without hindrance, is jealously prized. They are as valuable as the contents of the mines themselves, especially

in view of the fact that, in addition to the uranium oxide, other minerals present, but only in minute quantities, can be recovered as by-products upon a paying scale. Such is the remarkable transition which the great discovery of 1902 in the world of chemistry has wrought upon a corner of Britain.

The development of the radium industry resulted in prospectors the whole world over adding another ore—pitchblende—to the list of those to which it would pay them to devote attention in the course of their ramblings and adventures. This search culminated in further remarkable developments. It was found that another ore was able to contribute to the world's supply of radium. This was carnotite, a huge deposit of which was found in the Paradox Valley of Utah and Colorado. This announcement caused another excited wave to pass through prospecting circles, and, to guide the indefatigable mineral searchers in their quest, the American authorities extended some valuable advice, the Bureau of Mines issuing the following:

"Radium is found with uranium minerals only. Wherever uranium exists radium is also found in the mineral; and where there is no uranium radium has never been found. Uranium, and therefore radium, are found in this country (U.S.A.) in carnotite and its associated minerals, and also in pitchblende. Carnotite is a lemon-yellow coloured mineral usually found in pockets of sandstone deposits. The mineral may be in the form of light yellow specks disseminated through the sandstone, or as yellow incrustations in the cracks of the sandstone; or may be more or less massive, associated with blue, black or brown vanadium ores."

The discovery of carnotite in large quantities in the above-mentioned American states gave an additional impetus

to the radium concentration factories of Europe. The treatment of carnotite is much simpler and easier than that of pitchblende to obtain the basic uranium, although the subsequent processes are still complex and tedious. It is a distillation process, and is laborious from the circumstance that the radium is associated with so many other materials, the removal of which is extremely difficult. In the attempt to dissuade the shipment of the valuable carnotite to the European factories, and to encourage the creation of a domestic radium producing industry, the American Government established a temporary laboratory at Denver, so as to be within easy reach of the carnotite deposits. The chemists attached thereto at once set to work with a view to simplifying, if at all possible, the extraction of the precious substance. As a result of their investigation the chemists declared that the simplest way to extract uranium and the other rare minerals—vanadium radium—is to treat the ore or concentrate directly with boiling concentrated nitric or muriatic acid, and that even the vanadium and silica combinations can be completely decomposed after boiling for an hour in these acids. As a result of their work they stated that the cost of obtaining radium from carnotite in the well-equipped European factories was about £4 per milligram. At the time the radium itself was selling at £24 per milligram, so that the process was conducted at an attractive profit.

The American announcement that carnotite was capable of contributing appreciable quantities of radium spurred investigation in other countries. In South Australia a bed of this ore was discovered as long ago as 1906, and in 1910, following a closer investigation at the same place, Olary, where the carnotite was found, pitchblende was discovered.

When examined it was found to exhibit a high degree of radio-activity. This represented the first authentic discovery of this ore upon the Australian continent, and has been followed up, although development work was retarded by the war. Nevertheless, it has resulted in closer attention being devoted to possible radio-active minerals, among which must be mentioned "pilbarite," a mineral associated with monazite in Western Australia.

Uranium-bearing ores were also found at Radium Hill, and were promptly developed, the concentrates being forwarded to Sydney for treatment. As a matter of fact, the distinction of producing radium in the bromide form for the first time outside the highly privileged European factories belongs to Australia, a small quantity thereof having been produced at the Sydney works of the company owning the Radium Hill Mine in 1912. Within eleven months ending May, 1914, these works produced 239 milligrams of high grade radium preparation. While work had to be suspended as a result of the outbreak of hostilities, it is to be resumed as soon as possible. The chemist in charge of the establishment is confident that when the factory once again gets into its stride it will settle down to the regular production of radium to the value of £600 a week. Accordingly there is every reason to believe that Australia will become one of the most important radium supply countries of the world, more especially if it proves possible to attain a productive capacity of £31,000 per annum, since this will be equal to, if not in excess of, that of the European factories.

To-day there is a widespread commercial demand for radium in the form of a compound for the inscription of the hours upon watches, spirit levels, sand glasses, and instruments of various descriptions to enable readings to

be taken in the dark. The self-luminous dials of our watches and clocks are treated with a radio-active compound into the preparation of which radium salts enter. This industry has become firmly established in London, being, in fact, one of the new trades brought into existence by the war. One important development in connection with military applications deserves mention. This was the manufacture of glass tubes carrying radium for use with gun sights and other instruments of precision. The demand for these articles reached an enormous figure, and a highly ingenious apparatus was designed and built capable of filling and sealing these tubes at a rate exceeding 10,000 per day.

In this way the element which created such a tremendous sensation in 1902 as a scientific discovery, and was regarded as a towering scientific achievement, but one possessed of little beyond laboratory value, has been brought within the range of utilitarianism in a hundred and one ways. At the time the discovery was communicated to the world the outlook was far from being attractive, since commerce is not moved by mere laboratory conquests. The circumstance that the new mineral was worth anything from £6,000 to £10,000 a grain was decidedly adverse. Yet within two decades, as the result of persistent development, the rarest substance known to the world has been brought into everyday use, and in combination with articles which can be purchased for a few shillings.

CHAPTER XVI

Digging for Food for Plants

THE exploitation of the treasures of the earth is pursued from many motives, not the least important of which is that associated with the recovery of materials to feed our crops. Agriculture has long since been raised to the level of a science, and it has been found that to increase the yield per acre from our land the soil must be continuously fed with specific materials, among which may be mentioned nitrogen in the form of nitrates, potash and superphosphates.

The nitrate upon which the greatest measure of dependence is placed at present is saltpetre, the main supply of which comes from a small strip of land situate in one of the most uninviting parts of the world. The stretch of territory in question is about 430 miles in length, lying about 11,000 feet above the level of the Pacific, in the Chilian province of Antofagasta, a region where rain is unknown, where the sun shines the whole year round, and which is as arid as the Sahara, vegetation being unable to secure a foothold for the barest existence. Here is the largest bed of natural nitrate plant food to be found in any part of the world, the annual shipments of which exceed 2,000,000 tons, and which are bought by every country upon the surface of this earth where intensive agriculture is practised. Beside this figure the export from the beds of India, which aggregate 20,000 tons, appear so insignificant as to pass unnoticed. More

than this, however, is to be recorded. Although the Chilian beds are being indefatigably worked to save the world from starvation, it is estimated that the existing fields carry a reserve exceeding 246,000,000 tons, while it is quite possible that other parts of the higher Andes possess similar and perhaps larger deposits still, the time to work which has not yet arrived, because Chile is easily able to satisfy the world's present needs, large though they be.

How did this wonderful bed of plant food become deposited upon the roof of Chile? According to the geologist, whose business it is to work out such problems as these, the time was when the peaks of the Andes were covered by the waters of the Pacific. Then the internal forces of the earth began to work, pushing the sea bed upwards into the clouds. It was a slow process, and a huge basin was formed with the higher peaks constituting the rim. In this depression enormous quantities of seaweed were collected, and to a far greater density than is encountered in the Sargasso Sea to-day. In due course the fashioning of the rim of the basin was completed, forming an inland salt sea. It still served as a repository for seaweed which was lifted over the rim in large quantities by severe storms. Then the sun during periods of calm exercised his authority, drying up the water and bringing about the decay of the marine growth which had been flung into the depression. The conditions were highly favourable for that extraordinary form of germ life which we call nitrifying bacteria, and they converted the decomposed material into sodium nitrate. Nature kept the rain away, and at the same time prevented water draining into the basin, so that the conditions were remarkably favourable for the swarming trillions of microbes, and they did their work thoroughly, building up a thick

Photo. : World's Work.

MINING FOR PHOSPHATE

Natives at work in phosphate bed in Nauru Island, Central Pacific

stratum of this extremely valuable plant food, which was finally preserved from atmospheric and climatic influences by the deposition of a top layer of sand. Finally there was another mighty shiver which lifted the Andes to the present height and formation, and so elevated the nitrate bed.

Then came the mining expert. He was aware that saltpetre commanded a commercial value, although in those early days it was required essentially for the manufacture of gunpowder. However, as time passed the agricultural scientists discovered that it formed an invaluable plant food, and this discovery practically opened the contemporary Chilian nitrate era. Fortunately for those who set out to win this product, the bed of saltpetre or "caliche" lies near the surface, being sandwiched between the protective blanket or "costra" and a bed of soft clay, the vein varying in thickness from 6 inches to 16 feet.

The process followed is simple. The surface is roughly cleared. Drills are then set to work burrowing through the costra and caliche. Slow burning explosive charges are inserted in the holes and ignited. The explosion shatters the rock into large masses, while the separation of the costra from the caliche—which adhere together somewhat tightly—is effected by hammers.

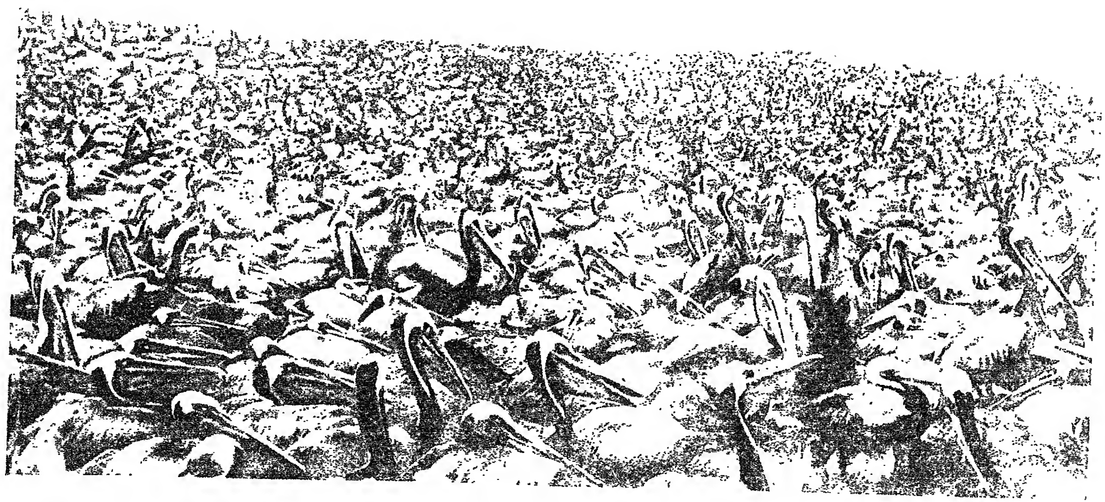
The broken rock is laden into carts and transferred to the "oficina" or recovery plants, where the saltpetre is reclaimed by a leaching process. Before being passed through the vats the crude caliche is subjected to a further pulverisation to reduce it to a size which will facilitate dissolving by the aid of hot water and steam. Some of these tanks are cylindrical in form, measure 15 feet in diameter by 30 feet high, while others are sufficiently large to permit cars made of perforated

iron to be lowered bodily into them with their loads, the liquor in the tank being heated by coils of steam pipe.

When the dissolution process has been completed the cars containing nothing but the insoluble residues are lifted out. To-day what are known as lixivating tanks are extensively used, the object of such an improvement being to reduce the loss of nitrates and to permit the poorer qualities of caliche to be profitably treated. Nevertheless the loss of saltpetre, even in the most efficiently conducted oficinas, averages about 15 per cent. But the introduction of improved methods has not only given higher yields but has enabled the residues, discarded years ago, and which were treated by less technical processes, to be re-treated to advantage. Again, by the modern process the iodine, which is a constituent of seaweed, can be recovered. Upon the completion of the recovery process the contents of the vats are permitted to stand for a few days to allow the saltpetre to crystallise. The liquid, or "mother liquor," as it is called, is drawn off to be used for treating further supplies of caliche, while the crystals are spread in the sun to dry and air, subsequently packed in bags for shipment, the saltpetre thus obtained carrying about 95 per cent. of sodium nitrate.

The superphosphate, which also constitutes a valuable plant food, is more freely distributed throughout the world. The greater part, however, is drawn from the arid countries of the north African continent fringing the Mediterranean. A certain amount of superphosphate manure is manufactured from suitable mineral obtainable in Britain, notably coprolite, beds of which exist in Cambridge and surrounding counties, but normally they do not pay, or rather have not paid, to exploit, the imported article being cheaper.

One of the richest beds of superphosphate is to be found



SEA BIRDS OF GUANO ISLANDS

A remarkable photograph taken on the Guano Islands where valuable sodium nitrate deposits are found

in two remotely situated Pacific Islands, mere dots in the vast expanse of salt water, but which for centuries have been the undisturbed home of myriads of sea-fowl. The birds found the home ideal from their point of view, inasmuch as the waters washing these islands—Ocean and Nauru Islands respectively—abound with fish, so that the feathered tribe multiplied exceedingly. The islands being their home the latter became covered with a thick deposit of guano. Nature at once set her wonderful chemical factory into operation on the various constituents—guano, coral rock, lime, rain and salt water—setting up various chemical reactions, in which periodic spells of rainless weather played no small part, culminating in the production of a yellowish hard rock which is now being exploited feverishly, being torn and wrested from its centuries-old bed by the aid of drills and explosives, and affording employment to thousands of Chinese, Japanese, as well as native toilers. The birds have long since forsaken the island, but during their prolonged undisturbed tenure they served Nature with sufficient material to permit the fabrication of a huge storehouse of one of the most useful foods for plant life, and one which is especially rich in the essential constituents.

In view of the remote situation of these islands and their comparative inaccessibility the circumstance that they have been transformed into thriving hives of industry is somewhat remarkable. But the farmlands of the world must have superphosphate as they must have saltpetre, and so the strange lonely treasure-house is a scene of astonishing activity and prosperity. The open sesame to this strange cave of Nature was found quite by accident. A sailor, during the course of a voyage in these lonely seas, encountered a piece of rock. He picked it up and took it with him,

animated by the thought that it would be excellent material from which to make marbles for his boys. But that stone got no farther than an office in Sydney, where it was used as a weight to keep the office door open on hot days. One day a member of the office staff, who indulged in chemical experiments and who happened to pick up this door weight, was attracted by its appearance. He took it home and investigated it to discover that it possessed excellent manurial constituents. He communicated his discovery to his principals, and henceforward every effort was made to trace whence the peculiar and hitherto spurned piece of apparent coral limestone had come. At last it was found to have been picked up on the beach of Ocean Island.

An expedition, including the chemist, was dispatched forthwith to the island to make a search upon the spot, and to survey the deposit, if any. The extent of the beds was found to exceed the most sanguine expectations, and immediately steps were taken to exploit the treasure. Capitalists were attracted to the spot, and it was not long before the shriek of locomotives and the clang of hammers and drills, punctuated at intervals with the sullen roar of explosives, disturbed the serenity of the island which had been ignored for centuries. The phosphate rock found a ready market, America and Japan promptly stepping in to take about half a million tons a year between them. Once the industry had been set going on Ocean Island the prospectors ventured to the adjacent Nauru Island. But this was German property, and the Germans failed to be impressed by the wealth of the deposits of rock which were found to exist. However, as the Germans would not work the rock the British undertaking established on Ocean Island offered to do so, and at last, after considerable delay, the requisite concession was granted.

The mineral is in abundance. It can either be mined from the solid fabric of the island, or can be recovered from the alluvial deposits. Both sources of supply are diligently being exploited by native labour, which is abundant, under white supervision. The rock is blasted out of the hillsides in open workings, much after the manner in which we quarry limestone, laden into baskets and transferred to railway trucks which bear it away to the treating plant. Here it is crushed and broken into sizes desired by the market, dried and then transferred to the huge storage bins, whence it is automatically transferred to railway cars, run down to the jetty, emptied into surf-boats, and thus carried to the waiting steamers.

Phosphate-mining in these distant and lonely islands stands as a fine tribute to British methods and organisation. No effort is spared to render the toilers thoroughly comfortable, and to remove every feeling of loneliness which their situation might provoke. All races engaged in the task of winning the rock live in absolute harmony, and are given full rein to gratify their own desires, whims and fancies. The quarters—the islands are in the tropical belt—leave nothing to be desired, and every convenience incidental to civilisation and a modern city is freely introduced. Wages are high, and there are all the comforts and attention one can desire, including even the free daily distribution of such indispensable commodities as ice, soap and cordials, so vital to the maintenance of health, especially in such a region. In this way the mining of phosphate in the heart of the vast Pacific has been converted into a highly profitable undertaking, the product to-day being in demand the whole world over. Even those countries which are able to point to domestic supplies of this plant-food express a preference

for the Pacific product owing to its rich and uniform quality.

Some of the loneliest islands in the Pacific have achieved commercial notoriety from their contribution to the food needs of the world. Those lying off Peru, far away from the beaten steamship track, offer an illustration of such activity. For centuries these islands have remained untenanted, except by the wildfowl living on the fish of the sea; they have nested here in their millions, and as a result immense deposits of guano have been formed. Some of these beds have been found to range up to 70 feet in depth, which suffices to indicate that the birds must have established their homes in these lonely spots for thousands of years and in their millions.

It was about a century ago that the value of this Peruvian guano first attracted serious notice. No rain is encountered upon these islands, the result being that the valuable constituents of the material have not been depreciated from dissolution by water. When the demand for fertilisers sprang up these islands attracted daring workers from all parts of the world, the guano being dug out and sent down suitable communicating facilities to be received in the holds of the sailing ships moored below. The richness of the guano being realised, the demand rose by leaps and bounds. Within about three-quarters of a century no fewer than 11,000,000 tons of this bird manure were dug out and transferred to various parts of the world to feed long-tilled land which was in sore need of regeneration.

The possibility of the supplies suffering exhaustion, as well as the wildfowl being driven from the islands, especially during the breeding season, caused the Peruvian Government to intervene. The exploitation of the guano was brought under severe control, the authorities first carrying out the

requisite steps to secure the protection of the birds and their invaluable contribution to the great fertiliser problem, subsequently transferring the authority to work the deposits to the Peruvian Corporation, the British undertaking formed to develop the various resources of the country, by whom the industry is now controlled. The output from these islands now averages about 100,000 tons a year. Other islands in these lonely waters, and lying within the dry belt, are being systematically prospected for guano in order to swell the reserves, and to give the islands which have been diligently worked a much-needed rest from mining activity. One such island has been found off the coast of Mexico, the guano deposits upon which are estimated to aggregate about 10,000,000 tons.

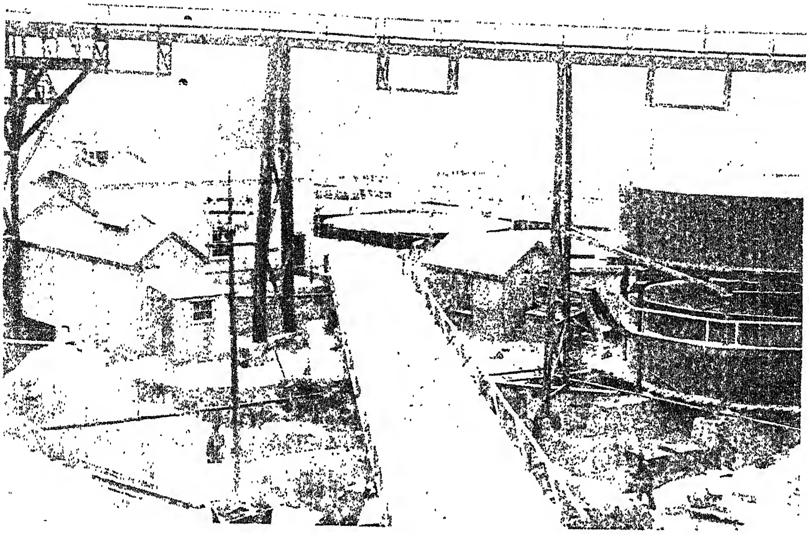
So far as potash is concerned the world has hitherto been almost entirely dependent upon Germany, because that country possessed the only known natural deposits of this valuable article, which is vital not only to agriculture, but to other trades, notably that identified with the manufacture of glass. Here another illustration of Nature working as a chemist is extended. The potash deposits are buried beneath a top layer of clay, forming an air- and water-tight seal, the food plant being found at varying depths, necessitating underground workings. The existence of this huge deposit, by the way, offers convincing testimony to the fact that Northern Germany once formed part of the floor of the Atlantic Ocean. It might almost be cited as a parallel to the formation of the Andes.

The plant food in greatest request is commercially known as kainit—kalium, a German word, being the technical term for the element potassium—but several other fertilisers of the potash group are made from other minerals found in the

locality forming part and parcel of the huge potash deposit. Each has a distinctive name according to the percentage of potash which it carries. The mines, which are well laid out and equipped, range in depth from 1,000 to 3,000 feet. Galleries are driven through the stratum, which is packed so hard as to demand the use of electric drills and explosives to bring it down in pieces, which are transferred to rope-hauled trucks running along well-laid tramways to the base of the shaft, to be hauled to the surface. The crude mineral is then ground to fine powder and graded according to its potash content under one or other of its various trade names.

Germany, possessing a world-wide monopoly in this indispensable commodity, did not fail to wield this weapon to her own advantage. It became a powerful political tool wherewith the German Government could threaten, browbeat and compel her trade rivals to submit to her desires. This task was facilitated by the potash mining firms forming a single concern—the Potash Syndicate—which had its representatives and experts in every country of the world. The output of potash was enormous, the normal daily production from the 200 salt works in operation in the country being 3,870,000 tons, while, in times of pressure, it could be increased to 6,000,000 tons every twenty-four hours.

The capital of the companies embraced in the Syndicate exceeds £80,000,000, and it gives employment to nearly 50,000 persons. Our annual potash purchases in the days before the war exceeded £600,000, while the United States spent nearly £3,000,000 a year upon the same commodity. The outbreak of war and consequent interruption of supplies hit us severely, the price of the article rising from about £8, its normal figure, to approximately £58 per ton. Even at this price it was forthcoming only in extremely limited



An up-to-date cyanide plant.

Natives at work in a phosphate bed

PRIMITIVE AND MODERN FORMS OF MINING

quantities. We were compelled to resort to materials carrying certain quantities of potash to satisfy our needs, but despite our efforts we failed to lift supply to the level of demand. Fortunately there is little risk of Germany being able to wield the potash monopoly weapon in her future negotiations with other nations inasmuch as one of the richest centres of supply has passed into the hands of France, and so we shall all be able to benefit from the fruits of competition.

Other materials are mined more or less extensively to serve as foods for our hungry soils, thereby enabling us to garner bigger and more frequent crops, but the foregoing represent those upon which the world is mainly dependent. In one or two instances, notably in the direction of nitrogenous plant food such as saltpetre, the chemist is striving hard to render us independent of the Chilian storehouse of Nature, while economy in general industrial practice is enabling the other commodities to be recovered from waste materials. But Nature's cave will remain our sheet anchor in this connection for many, many years to come, and thus will offer ample scope for the exercise of human effort and enterprise.

CHAPTER XVII

The Prince of Jewels

WHAT platinum is to the utilitarian mineral world the diamond is to the extensive kingdom of gems and jewels—the prince. In point of value it is without an equal, although this distinction is entirely due to artificial influences. It is the slave of vogue. If Dame Fashion were to turn round and to spurn the scintillating carbon, as she did jet some years ago, the price it at present commands would collapse. Stones which under contemporary conditions realise thousands of pounds would fail to fetch a few shillings. The diamond, unlike the minerals, is of but little value to industry. This is not to say that it does not possess certain possible industrial applications, but so far industry, having been precluded from enlisting its service from motives of expense, has been able to rub along without it, and could continue to do so. Fortunately for the craft, the prospector and the mining engineer, Madame Mode, with that caprice which is her prerogative, has not yet issued a decree against the diamond, and so it is able to wield its autocratic sway in the realm of gems and jewels.

In another chapter I have referred to the graphite-mining industry of Ceylon. The diamond belongs to this family, although there would appear to be as much in common between graphite and diamond as there is between the white man and the negro. Yet both are formed of one of the com-

monest of elements—carbon. If one has command of a sufficiently high degree of heat the carbon can be converted into gas. Then if one be possessed of sufficient pressure and can bring it to bear upon that gas, squeezing it so tremendously as to convert it into a crystalline form one would produce a diamond. It is a simple, straightforward operation. The only obstacle is the command of a sufficiently intense temperature and pressure respectively, although to-day the heat side of the problem offers no difficulty. The electric furnace can provide all that is required in this direction. But the pressure issue is not so easily overcome. This is a secret which Nature still preserves. Man, by resort to wonderful mechanical devices, can get pressures up to 15,000 and 20,000 tons per square inch, but this is a caress in comparison with what is exercised by Nature to crystallise carbon.

The fact that diamond production is synthetically feasible was convincingly demonstrated by Henri Moissan, the famous French scientist. He took some pieces of charcoal and iron. He plunged them into the electric furnace and switched on the current. The carbon was gasified and the iron was reduced to a fluid condition through which the gaseous carbon bubbled. Then he suddenly cooled the iron. Now molten iron, and for that matter all minerals, including rock, shrink perceptibly in the process of cooling and solidifying, and in so doing any foreign substance which may happen to be present is submitted to a titanic squeeze. It was so in this instance. When the iron had cooled it was dissolved in acid and the carbon was retrieved in minute glittering particles—diamonds.

Thus, in the laboratory, within the limited facilities at his disposal, the French scientist reproduced the cycle of Nature.

The internal fires of the earth are continually gasifying carbon which seeks to escape. It finds its outlet through the natural vents offered by the live volcanoes. Much of the carbon makes its escape into the air without difficulty. Other perceptible quantities encounter obstructions, in the form of liquid earth and rock. They rise through this fluid seal until they lose power or give up the effort in despair, become trapped in the molten mass to be held prisoner. In due course the molten matter cools, solidifies, shrinks, and in so doing crystallises the carbon. This is the manner in which the diamonds of South Africa were formed, and they were only thrown into the outer rind of this sphere by one of those cataclysmic convulsions which are encountered from time to time.

There is a tendency to believe that Nature has been so uncommonly discriminating in her distribution of diamonds as to have planted the whole of her readily accessible stock in South Africa. This is erroneous. Diamonds are found in all parts of the world, and were known long before the fields of Kimberley were ever thought of. But the South African stone holds the field because it is regarded as excelling all others in beauty and quality, and so rules the market.

"Here be diamonds!" Such was the laconic inscription scrawled on a map, or practically what was only a rough chart intended to serve as a map, by a missionary in 1750. And the point thus indicated was situate on the dismal waterless veldt of South Africa. But whether the missionary was regarded as a practical joker, or whether the true value of the diamond failed to be appreciated at that time, is not quite clear. But what is certain is that the intimation thus conveyed failed to arouse the slightest interest for a century.

Even then the waterless desert would probably have been regarded as little more than a hunting-ground for the missionary among the Griquas, had it not been for a little boy, his mother, a Dutch farmer, a travelling trader, a commissioner and an apothecary who made a bet, and the mineralogist whose assistance was sought to decide the wager. The little boy picked up a bright pebble which looked something like the glass balls with which we seal our bottles of mineral waters. It attracted his fancy, and he showed it to his mother, but it excited no feminine interest. The boy showed it to a neighbouring farmer, Van Niekerk, who offered to buy it, but was smilingly told by the Dutch housewife to put it in his pocket since he had taken a fancy to it.

The Dutch farmer knew nothing about diamonds, but impressed by its unusual appearance thought there might be something in it and did slip it into his pocket, only to pass it on to the travelling trader, John Reilly, to see if it was worth anything. Reilly handed it to a commissioner, named Boyes, who, finding it would scratch glass, ventured the thought that it might be a diamond, but his friend the apothecary chemist pooh-poohed the suggestion and said it was a topaz—perhaps! He bet Boyes a new hat that it was more likely to be a topaz than a diamond. So, to settle the bet, the stone was sent to the mineralogist of Cape Colony, but evidently no one thought much of it because it was posted in an unsealed envelope to save expense!

The reply of the mineralogist was startling. He declared it was a diamond weighing 21¼ carats and worth £500. The Governor-General at the Cape bought the stone for that sum, Boyes got a new hat, Reilly and Van Niekirk shared £500 between them, and the Dutch farmer was so satisfied with the deal as to set out to see if he could get any more

stones of such value for nothing. His luck did not desert him. He found a similar quaint glassy-looking pebble in the hands of a Griqua shepherd boy. He obtained the stone in exchange for 500 sheep, ten oxen and a horse, but drove a fine bargain because the pebble, which weighed 83½ carats, netted the astute Dutchman £11,000, and was subsequently sold for £25,000 to become the far-famed "Star of South Africa" diamond.

These two sensational finds within a few weeks in the year 1867 were quite sufficient to fire the imagination of prospectors and treasure-seekers the whole world over. Evidently in the Orange Free State fortunes could be picked up among the stones, so a wild stampede ensued. It was pretty hard going, especially the climb to the waterless desert to the spot where prospects proved that diamonds were to be found by digging for them. At a later date, when someone recalled the old missionary map, it was perused out of curiosity, and it was discovered that the point marked thereon did correspond with the spot at which the gem was being found in such abundance—which was nicknamed "New Rush," afterwards Kimberley.

It was speedily discovered that the precious gems were only to be found in a severely limited area of about 13 acres. Never was a small patch of land exploited more thoroughly than this. The mining laws of the day were to the point—one man, one claim. In fact, it was more drastic because neither a partnership nor a company could legally hold more than one claim, and that claim measured exactly 31 feet long by 31 feet wide! Superficially it was but a patch, no bigger than a suburban villa garden; but although the miner could not reach out on either side, he was at liberty to dig as deeply as he felt so disposed. What he was denied in area he was

allowed in depth. So frenzied were the diamond-seekers that every foot of the paying earth was claimed. This is not surprising when it is remembered that the earth appeared to be as freely dotted with diamonds as is a strawberry with pips. The crudest of washing devices were used, and, although undoubtedly many small stones were lost during the initial rush, fortune did not trickle, but poured in torrential volume upon those who dared the journey to "New Rush." Many of the pioneers became possessed within a few minutes of the equivalent of more sovereigns than they could ever hope to count.

That 13 acres presented a strange spectacle. Hundreds of men swarmed over the tract digging frantically. The dirt flew in true earnest; so much so that within a few years an immense hole had been dug, 1,000 feet across, the bottom presenting the most bizarre effect imaginable. Some of the miners had dug more deeply than their colleagues, and so the floor of the pit presented a striking resemblance to a long since abandoned colony of cliff-dwellers in a cañon such as is to be found in the United States. No two claims were at the one level. Some had yielded more freely than others. A claim worked to a depth of 200 feet or more was frowned upon by the one next door, the wall of which rose up sheer for 80 or 100 feet. The deeper claims were reached by ladders, the adjacent owners courteously allowing the deep digging miner to reach his working via their property.

This extraordinary pit, the most remarkable open-working ever recorded in the whole history of mining, was rimmed on every side by a wall of rock, which the miners picturesquely called the "reef." This enclosing wall represented the limits of mining activity; the prospectors and workers promptly found that it was useless to burrow into

the reef for treasure for the simple reason that it did not carry any of the precious crystallised carbon. Along this reef, on one side, extended a primitive wooden staging, and it was as long as the mine itself. Upon this staging in three continuous rows, one above the other, wooden winding drums were disposed. Each drum was about four feet in diameter, was of crude construction, carried a coil of wire, and was actuated by four men. There was a cable and drum to each claim, and, bearing in mind the number of claims being worked, it will be seen that there was a formidable array of drums and a bewildering maze of cables. The latter ran at all angles to the horizontal. Those serving the claims immediately abutting on the reef were almost vertical; those serving on the opposite side of the pit were inclined more towards the horizontal. From the bottom of the pit it seemed as if a huge cobweb was sprawled across the open working, while when viewed from the rock at either end it presented a striking loom of activity with the wires reaching from every corner of the pit and converging upon the staging at the side.

Upon each claim a post was erected to form the mine-end of the cable, and along this aerial way the miners sent the buckets laden with the valuable blue earth excavated from their respective holdings. Through providing a drum, cable and bucket to each claim the possibility of dispute arising in regard to any removed earth, and its subsequent yield, was effectively eliminated. In the first instance the buckets were fashioned from ox-hide, while the cableways were operated by stalwart Kaffirs who had speedily been attracted to the scene, lured by the chance to get rich quickly.

As explained, each miner was allowed to hold and to work a small tract measuring 31 by 31 feet, and for this privilege

he paid a tax of 10s. a month to the Government. This served to defray the cost of awarding the claims and to see that no miner secured an inch beyond what he was entitled, the ground being surveyed and cut up before working was permitted. But the miners paid the imposition readily. Now, although each claim was merely a patch, the ground was so rich as to lead to the practice of claims being subdivided and sublet, the result being that some men were exploiting areas measuring about ten feet square, or even less. In these circumstances the pit which normally was somewhat congested became even more so. Troubles began to arise as the miners frenziedly dug down deeper and deeper. No attempt to shore up an adjacent claim was made; it was generally believed that the blue ground was sufficiently hard and stable to stand up unaided. As the pits increased in depth land slides began to get frequent. A projecting claim would slip into the cavity beside it, and trouble would instantly arise because it was difficult to decide whether the fallen earth, possibly carrying diamonds, now belonged to the claim upon which it had descended or to that from which it had slipped. The miners working under the wall of the reef suffered most from this trouble, which speedily developed into a serious danger. Again, as the pit grew in size and depth the arch-enemy of the miner throughout the world began to assert itself. It was discovered that while slipping earth from adjacent claims undoubtedly constituted an exasperating difficulty, the dangers to be encountered from water were far more to be dreaded. Water brought work completely to a standstill, because as fast as it was removed it reappeared. The "New Rush" might be located upon a sterile desert, but water could find its way into the diamond pit in plenty.

The recovery of the diamonds was as primitive as the working of the earth. If the miner encountered any stones while shovelling the valuable earth into his bucket he slipped them into his pocket. But for the most part the gems were recovered from the sorting facilities which were installed upon the floor of the reef. At first the blue ground was broken up and the gems picked out by hand from the pay-dirt in the dry condition, but subsequently the wet process was adopted, the earth being sluiced as is the practice in alluvial gold- and tin-mining. Fortunately labour was cheap, hordes of Kaffirs being readily available for a shilling or two a day, and these workmen played a very prominent part in winning the early treasure trove from the famous blue earth of Kimberley.

As time passed the miners soon found that open primitive working was far from being completely attractive. The pit was overcrowded. When it is stated that over 3,000 claims were being worked in an area of 1½ square mile some idea of the congestion may be gathered. Collapsing earth and inundation were two grave menaces, but they were insignificant compared with the other difficulties with which the miners now became confronted. The wealth to be won from these few acres attracted the flotsam and jetsam of the trading community from all corners of the earth. They did not make any attempt to work themselves; it was far easier to corrupt a Kaffir, induce him to conceal the more valuable stones, and to part with them illicitly. Some of these unscrupulous hangers-on to the mine did not hesitate to resort to diamond stealing if extended the opportunity. Illicit diamond buying became an organised traffic and survives to this day, although the traffickers now find it extremely difficult to conduct their nefarious practices. The early miners sought to check the

evil by securing authority to accommodate the Kaffir labourers in camps or compounds enclosed by a formidable stockade, and from which they were not allowed to pass during their term of employment, which was usually for three months. But even this drastic arrangement failed to suppress the illicit traffic.

The reaction was inevitable. As the claims sunk deeper and deeper the problems assailing the miners became more formidable. Moreover, the expense of working the ground increased rapidly, and in some instances proved to be in excess of the revenue earned. The individual treasure-seeker is a curious individual. No matter what the proved wealth of a "strike" may be he will decline to work it unless he reaps a steady profit from his property. Directly the situation runs against him he will either abandon his claim or sell it for what it will fetch. It was so at Kimberley. Within a few years the stage was reached when small individual-claim working could no longer be regarded as profitable. The frenzied treasure-seekers commenced to abandon their claims, and these became derelict. In so doing they grew into a menace to those remaining, who became aggravated. The outlook for Kimberley was ominous: the primitive and makeshift had run their course; to keep the industry alive modern science would have to step in.

It was at this juncture that that big Englishman, Cecil Rhodes, appeared upon the scene. With his wonderful perspicacity and imagination he grasped the situation in an instant and at once determined to put the industry firmly and substantially upon its feet. His first move was to bring the country in which Kimberley was situate under the British flag. He drove a bargain with the Chief of the Griquas who held sway over the country, whereby 15,917 square miles,

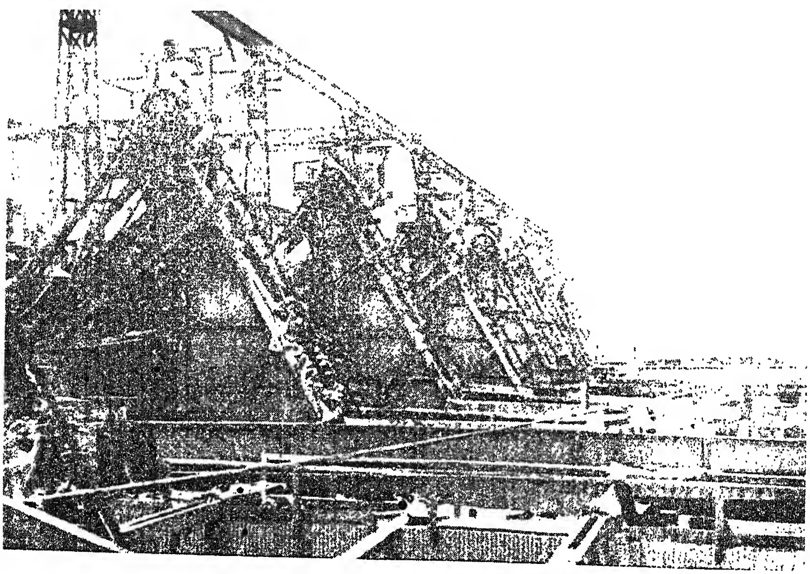
including the diamond fields, were transferred to Great Britain. Then he set to work to secure a revision of the domestic mining laws which in their existing state constituted an insuperable barrier to the fulfilment of his ambitions. He had the "one man, one claim" statute repealed. This enabled an individual or a company to secure control of just as many properties as he or it felt disposed to acquire or could purchase.

He now carried on an active campaign among the individual claim-holders, suggesting that they should sell out and allow the mines to be worked as a single entity which would permit the introduction of machinery, and the installation of highly efficient wealth-recovery systems. They listened to his arguments, appreciated their force and took advantage of the terms he extended. In this manner the number of claim-holders and individual mine-workers became reduced, and although for a time competition raged between opposing magnates for the acquisition of the properties, the Empire-builder finally fulfilled his dream. All the claims became consolidated into one homogeneous whole, to become known throughout the world as the De Beers Consolidated Mines, Limited, with the most comprehensive charter ever granted to a private organisation.

The foundation of this enterprise in 1888 constituted the turning point in the history of the diamond industry of South Africa. The primitive and obsolete, which had reigned unfettered for twenty years, were swept away. System, organisation and ultra-modernity took its place. While his plans for consummating his great idea were maturing the presiding genius met a young, imaginative American mining engineer of the push-and-go order, Mr. Gardner F. Williams, who had been prospecting in another part of the

THE PREMIER DIAMOND MINE, JOHANNESBURG

A general view of the open workings.



THE PREMIER DIAMOND MINE

Surface plant for dealing with the blue clay.

big African continent. A warm friendship sprang up between them which was stimulated by the American elaborating just how he would operate the diamond field if it ever came into his hands. Mr. Rhodes cabled to this young engineer who was spending a holiday with his parents in the States, offering him the control of the diamond mines, extending him a free hand to do just what he thought fit, and to spare no expense in fulfilling his schemes. The offer was accepted and Mr. Williams was soon back again at Kimberley. Once again the dirt speedily commenced to fly, but in a different manner. The taking over of the reins of the De Beers interests upon the spot by the energetic American engineer actually preceded the establishment of the great diamond mining monopoly, but at the time he went into office the big scheme was well under way so that the manager was ready to act the moment the consolidation was consummated.

Open working gave way to underground mining. This treasure-house is really the crater of an extinct volcano charged with the blue earth in which the diamonds—and useless pebbles—are found. And, so far as present prospects have been conducted, the whole of this diamantiferous soil forming the Kimberley district is found within less than forty square miles. For a time this was regarded as constituting the whole of the diamond-bearing country in South Africa, but within the past few years other areas have been found, so that Kimberley no longer holds the monopoly except in regard to that arbitrary and fickle factor—quality.

Mining for diamonds does not differ from other quests for wealth contained in the earth except in detail. The galleries are driven literally from the central shaft penetrating the blue ground. This is a kind of clay or marl, which, under pressure and relative absence of water, has become as

dense and as hard as a rock. Holes are driven into the mass by means of a hammer and chisel, dynamite charges are inserted, and the face of the bearing ground shattered. The Kaffirs play a prominent part in diamond winning. They ply the hammer and chisel under white supervision, while the white workers actuate what mechanical drills are used, for the reason that skill is demanded in their manipulation. The mines offer steady employment to about 15,000 Kaffirs in the underground workings alone, this force being distributed among five mines. Then there are the surface workers, so that the army of native toilers ranges between 25,000 and 30,000. This population is still accommodated in compounds for the simple reason that the Illicit Diamond Buyer—I.D.B. as he is called for short—despite the efforts which have been made to render his trade exceedingly unhealthy, still flourishes more or less, and to further his own ends he would be quick to turn to account the native, who is fully alive to the value of these stones and the possibilities of surreptitious dealings therein. The natives are not permitted to leave the compounds under any pretext whatever, except to return to their kraals upon the termination of their contracts, which are for periods of three months, but many of these workers have never been out of their reservations for three years or more. Labour is purely voluntary, and there is a certain amount of keenness to secure employment at the mines, inasmuch as toiling for diamonds offers the Kaffir the means to become wealthy in the eyes of his compatriots, the extent of his wealth being measured by the number of his wives.

Mining is continued day and night, week in and week out, the whole year round without intermission. As rapidly as the blue ground is blasted from its bed by the dynamite it is

hurried along the galleries, some of which are 1,400 feet long, to the main shaft, where it is discharged into a huge skip, to be hauled rapidly to the surface by powerful winding-engines.

Reaching the mouth of the shaft the ore is borne to huge tracts of levelled cleaned ground called "floors," upon which it is dumped and spread out. In the aggregate these "floors" cover an immense area, those of one mine extending for five miles. Each floor measures about 400 feet each way, and the ore is spread over the surface to form a layer about 10 inches in thickness. It is left fully exposed to the air, and under the influences of weather rapidly disintegrates. This action is accelerated by harrowing the ore as if it were a ploughed field, so that the underlying earth is brought to the surface to become decomposed. This gradual pulverisation being a natural process, the complete disintegration of a spread upon the floor takes several months. At the end of the predetermined period should any lumps be found to have resisted weathering, they are collected and transferred to the crushing machine which promptly reduces them to powder.

The break up of the blue earth completed, it is conveyed to the washer which carries away the loose, soft, friable dirt, leaving behind only hard pebbles, sand, diamonds and other gems which may happen to be present. This residue is then carried to the pulsator, the novel and wonderful plant which by automatic mechanical agency does the work formerly fulfilled by hand, and in a much more efficient manner. It will select nothing but diamonds, and it represents the practical utilisation of an idea which was evolved by one of the men engaged at the mines.

Mr. Gardner Williams was striving hard to devise a mechanical selector; and although he resorted to many clever

expedients, he failed to secure the satisfactory working he desired. Obviously, such an apparatus must work with infallibility, and must not be discriminating in its work. That is to say, it must pick out the small stones as readily as it selects the larger gems.

One day a workman came to him. He had discovered how to separate the diamonds from the useless dross exclusively by automatic agency and by a means which could not fail. The idea was explained, and, like all great solutions to perplexing problems, was astonishing from its extreme simplicity. This workman had discovered that the raw stones have a peculiar affinity for fat; if a travelling band be covered with grease of a certain consistency, and then be sprinkled with the diamond-bearing residue from the washing-plant, it would allow the pebbles and sand to pass on without hindrance, but would arrest every and any diamond, no matter what its shape and size might be. The discovery was subjected to the most searching tests, and, as the workman maintained, was infallible in its working. Thereupon it was adopted, and to-day constitutes one of the most fascinating of the many wonderful expressions of mechanical ingenuity to be seen at these mines.

The diamonds are so fond of the fat, which resembles a kind of tallow, that they will often bury themselves in the thick coating which is spread on the surface of the pulsator, as the automatic separator is called. Accordingly, the fat with its precious contents is scraped off, to be transferred to a cauldron. Here, by the application of gentle heat the fat is rendered fluid, and so can be poured off, leaving the diamonds, which have sunk to the bottom of the vessel, to be turned out ready for grading and marketing. Grading is done by hand by experienced workmen, and the stones are

divided into ten main groups, the first eight of which are sub-classified. The diamonds are sold in the rough, the purchasers completing their own arrangements for cutting and dressing the gems for the market. There is one novel feature of the mining industry which is worth recording. All transactions in the raw stones are conducted upon a cash basis; there is no credit.

The outstanding feature of the De Beers mines, which offers a striking tribute to the organising and imaginative genius of its American controller, is the mechanical equipment. Kaffir labour is cheap, but it has its drawbacks and limitations. On the other hand, white labour is expensive. Accordingly as much work as possible is fulfilled by mechanism. There are powerful winding engines for handling the material and men passing in and out of the underground workings. Upon the surface is an intricate network of aerial railways bearing the suspended trucks of ore to the "floors." These are automatically loaded at the pit mouth, and travel at high speed to the floor where the blue earth is emptied from the carriers automatically. Turning over the distributed blue clay while it is weathering is performed by the aid of huge harrows working on the cable system. At each end of the floor is a powerful traction engine, round a drum mounted on which passes an endless cable. The harrow is clipped to this cable, and is thus hauled to and fro across the floor, working from one side to the other, so that the decomposing clay suffers complete turning over. It is an application to the mining industry of the well known cable ploughing methods so familiar upon the farms of this country. So prominent a part does mechanism play in the operation of these mines, and so vital is it to keep pace with progress, that the De Beers Company does not hesitate to

spend £250,000, £500,000, or even £1,000,000 upon new and further plant when the man at the helm considers such action necessary.

But although the world to-day depends on Kimberley for its diamond supplies it was not always thus, while the future is likely to reveal other centres of production. Previous to the discovery of the South African fields the Brazilian jewel held sway. It only suffered eclipse because the stone from South Africa is declared to be superior in quality. As a matter of fact, none of the most famous diamonds of the world has come from the Kimberley fields. The largest, the "Braganza," which weighs 1,680 carats in the rough, was unearthed in Brazil, as was also the "Star of the South," which scales 254 carats. If quality be the deciding factor, then pride of place for diamonds goes to India, the stones from which country are of unrivalled beauty, and certainly are appreciated in this respect because they command the highest price. The finest diamonds in the world, many having a thrilling and romantic history, were found in India. Among these may be mentioned the "Great Mogul," which is believed to have been lost, since it has not been seen since 1665, and which weighed 787½ carats; the "Koh-i-noor," reduced from its original 186$\frac{1}{16}$ carats to 102½ carats; the "Orloff," weighing 193 carats, sold in Amsterdam for £90,000 and an annuity of £4,000 to Count Orloff, and which forms, or formed, the chief ornament in the Imperial sceptre of the Czar of Russia; the "Moon of the Mountains," which is also included in the Imperial Muscovite crown jewels. But probably the most famous Indian jewel of this character is the "Pitt" or "Regent" diamond. It was bought in the rough state by the grandfather of the celebrated British statesman (for £20,400) who, after having it

cut and polished, sold it for £135,000 to the Duke of Orleans. To-day it is valued at over £1,000,000.

Although the diamonds found in India have attained such an extraordinary value and world-wide fame, and although India was the only known diamond-yielding country for centuries, prospecting for diamonds in our Eastern Empire has never developed into an industry. There are three proved areas, but the stones are found only in alluvial workings. They have never yet been tracked to their mother-earth as has been the case upon the African continent. Alluvium working is prosecuted more or less diligently, but the yield is really negligible.

In the opening days of 1905 South Africa was thrown into another fever of excitement by the discovery of another huge diamond which really heralded the debut of a new diamond-field. Experts and others for years had been disposed to maintain that while diamonds might possibly be found outside the Kimberley district, they would never compare with the stones obtained at the latter place, either in size or quality. This theory was rudely shattered upon the development of the Premier Mines near Pretoria, the manager of which was formerly employed at Kimberley and thus had gained as much knowledge as was possible to acquire concerning the occurrence of this jewel. On January 27th, of the above-mentioned year, while proceeding round the workings his eye was caught by a stone projecting from some debris. He promptly picked it up and at once realised that he had indeed made a find. The find was not the most remarkable feature; he was amazed at its size. It was weighed and found to eclipse any diamond which ever had been found, turning the scale at no less than 3,253¾ carats—about 1⅓ pound. It created a world-wide sensation. To-

day the "Cullinan" diamond, as it is called, holds pride of place in every way. The rough stone was subsequently purchased by the Government of South Africa for £150,000 and presented to King Edward VII. It was cut into nine pieces, and now forms part of the Royal regalia.

Another mild sensation was created by German prospectors finding this stone in South-west Africa in the neighbourhood of Lüderitz Bay. Being a German colony the discovery was hailed with delight, since now Germany was rendered independent of the British monopoly in the mining, cutting and marketing of a jewel in universal request. Arrangements were completed to foster and to develop the new industry. But these hopes have now been finally extinguished as a result of the war. Recently the German deposits were brought to the fore by the discovery of a continuation of the deposits off the coast which resulted in an application for a concession to exploit the submarine treasure-house by the aid of suitable dredging and other methods. From this it will be seen that the area of diamantiferous earth is rapidly extending, and, although at the moment it is possible to keep the supplies to the market down and the price up, successive developments are rendering this control of supply and demand, ever a difficult law to keep in leash to individual satisfaction, a matter of difficulty. Its value is purely artificial and must dwindle as it becomes realised that the world contains more diamonds than fickle fashion can absorb.

The high price of the South African form of crystallised carbon has reacted somewhat adversely against certain industrial developments. Although the diamond is essentially an article for personal adornment it is in request for certain more prosaic utilitarian purposes. This has been mainly due

to the increasing use of the diamond drill in mineral-searching operations. Unable to afford the high prices demanded for the South African product, commercial enterprise has turned elsewhere for a similar product, and has discovered just what it desires in what is called the "black" diamond. The term "black" diamond is usually applied as a colloquialism to coal, but, as a matter of fact, it is a strict commercial term to distinguish the industrial jewel from that entering so extensively into the field of artistic embellishment. The black diamond is really divided into two classes, the carbon and bort respectively. The first is closely allied to the genuine article, occurring in a crystal form, equal to its more highly treasured brother in point of hardness but of less density, while it is greyish or black in colour, from which characteristic it derives its distinctive name. The bort is of a similar tinge, but more or less truly spherical.

At present this class of diamond is found in only two places. The one is Cape of Good Hope; the other Brazil. At the moment only the Brazilian deposits are being worked, the richest occurrence being in the province of Bahia. It is recovered from the bed of the River Paragason and its tributary the San Antonio, as well as from the sides of the Sierra des Levras. This field is somewhat extensive, and recovery does not appear to present any great difficulty, the mineral being found in a gravel resting upon a layer of clay. The field commenced to attract serious attention in the eighties of the nineteenth century, but it was not until 1890 that any decisive demand arose for the peculiarly hard carbon for drills and other implements, for facing which it is eminently suited.

Owing to the comparative remoteness of the "field,"

development has not been carried out with any pronounced zeal. Primitive working obtains. A point in the river which prospecting has proved to be attractive is marked with a pole. The native, equipped with a bag having its mouth distended by an iron hoop, slips down the pole, hurriedly fills the bag with silt, and then reascends. Time after time he dives in this manner to repeat the operation, using a fresh bag upon each successive descent into the water. The bags of gravel, as brought to the surface, are taken ashore to be stored for treatment during the wet season, when working in the river becomes impossible, owing to depth of water and velocity of the current.

Under such conditions of working the claim has to be selected with care. The water must not exceed 20 feet in depth, while it must be a part of the river where the current is easy. The dry season being of approximately six months' duration, the prevailing low water enables diving and excavation of the silt to be carried on without intermission for approximately half the year. The remaining six months are spent in washing the dirt recovered during diving. The alluvium is washed in the usual manner, enabling the carbons to be isolated. If "dry" digging be favoured, as upon the mountain slopes, tunnels are driven into the gravel which has been located, and the earth removed is stacked against the recurrence of the rainy period when water becomes available in plenty. The industry is profitable, the stones finding a ready market in Bahia owing to the increasing demand for the carbon for the industrial uses mentioned. The price ranges from about £3 per carat upwards. Naturally they vary widely in size, many being scarcely distinguishable from the grains of sand, but others are of appreciable weight. One large crystal was discovered in

1894 and realised £4,000 when sold in Paris. But, curiously enough, the large carbon is not highly prized. It has to be cut up to adapt it for its designed duty, and much waste is incurred in the process. Crystals weighing about three carats meet with the widest approval and fetch the best prices. As the demand for this class of commercial diamond increases it is only logical to anticipate that modern methods, in the form of the dredger, will be introduced, in which event prices will suffer severe reduction. But the mining for this form of crystallised carbon suffices to prove that the diamond has its place in industry as well as in the arts; as a tool as well as an ornament.

CHAPTER XVIII

The Search for the Smoker's Friend

HOW many of the thousands who seek the solace offered by "My Lady Nicotine" through the medium of the briar realise that to obtain the raw material so universally favoured it is necessary to delve into the crust of Mother Earth. Even the meerschaum has its home in the soil, and has to be mined just as if it were coal or iron. So far as the clay companion is concerned its mineral origin is obvious, and it may be remarked that the material from which it is fashioned is fairly closely related to the meerschaum.

The highest grades of briar from which the bowl is wrought do not come from France, although described as French briar, but from Italy. The term arises from the fact that the French product was first used for the purpose. The genuine French briar continues to hold the field, notwithstanding the fact that it is somewhat more expensive than its colleague from other districts. Strange to say, the pipe is not made from briar at all, this conveying the idea of the wood being cut from the branch growth of a tree. Briar is the anglicisation of the French word *bruyère,* meaning the root of the heather; but in course of time, as a result of the material becoming more familiar to the market, the word *bruyère* became corrupted into briar, and remains with us to this day.

Although applying to the root of the heather, this is not

to say that the underground part of all vegetation of this category is adapted to the manufacture of pipes. French briar, properly so-called, is the root of the heather which flourishes upon the slopes of the Tuscan Alps, of the mountains of Corsica, and Les Alpes Maritimes near Nice, but so far as the last-named source of supply is concerned, this has long since been exhausted. What root remains would probably prove unprofitable to work. As a result, the Tuscan Alps now constitute the centre of production. Corsica still contributes a certain quantity to satisfy the smoker's fastidious needs, but the product is scarcely up to the quality of the article derived from Italy.

How the root of the heather came to be used for the making of pipes forms an interesting little story. The heather which flourished in profusion was discovered to be first-class material for the fashioning of brooms, and the communal authorities granted the peasants permission to harvest the growth for this purpose. Repeated cutting of the heather brought about considerable development of the roots of the plant. One or two of these roots, becoming detached accidentally from the soil, were subject to scrutiny, idle at first, but they were observed to have assumed somewhat significant dimensions and weight, and to be formed of a prettily grained, dense, hard wood.

When snuff-taking constituted the vogue the diligent Swiss wood home workers devoted their energies to the making of small and attractive boxes for the devotees of this habit. Boxwood from its density, hardness and grain was the most popular material, and the Swiss-made snuff-boxes achieved a wide vogue, being in keen request throughout Europe. The demand, in fact, assumed such proportions as to lead to the speedy depletion of the home supplies of the

requisite raw material, with the result that search had to be made for another comparable indigenous wood. The heather roots which had been torn up inadvertently were examined, tested, and were found to be adapted in every respect to the work in question. Indeed they presented a prettier and more attractive box owing to the picturesque bird's-eye grain. Forthwith heather roots commenced to be used for this novel trade.

Unhappily, about this time, the snuff-box suddenly fell upon evil days, fickle Madame Mode decreeing that snuff-taking was not *de rigueur*. But as the taking of snuff went out, pipe smoking came in, and so wood was required for the manufacture of pipes. The Swiss workers, finding the market for their handiwork imperilled and their long stockings in jeopardy of depletion, adapted themselves to the change in fashion. They became pipe-makers, and for years they held the market in this field of endeavour. Having discovered the suitability of the heather root for the one purpose, they promptly investigated to ascertain whether it might not be used with equal success in the second field. To them such adaptation meant a continuance of prosperity. The tools and skill which had been necessary to make the snuff-boxes were equally in demand for the fabrication of pipes. The experiment proved an instant success, the briar bowls, when polished, making an irresistible appeal to the smoker.

Pipe-making developed rapidly as an industry, and the consumption of the wood progressed at an extremely rapid rate, seeing that, on the average, only two pipes can be made from one root. The peasants sought permission from the authorities to dig up the *bruyère* roots, and the latter, realising the opportunity to secure the clearing of the land for

general agriculture and vineyards without incurring a penny of expense, consented. Accordingly at the proper season of the year, when, according to the experience gathered, the roots should be excavated to catch the wood in its prime, harvesting set in. But, as the time passed, the authorities heard whisperings of the peasants making money out of these roots, and they conducted discreet inquiries. Then for the first time they learned that the scrub, the free clearing of the mountain slopes which had extended them such unmitigated delight, was being conducted to high profit by the peasants. The rubbish was feeding an industry. Thereupon *bruyère* root collecting was made illegal; all permits were summarily cancelled. Instead of the peasants being free to collect the apparently valueless scrub, they are only permitted to do so now upon payment of a prescribed sum, in return for which they are granted a licence.

Although the official action may seem to appear churlish, it certainly has proved beneficial. The indiscriminate destruction of the heather root was arrested. The official action led to the scrub being treated in a scientific, cultivated manner, so as to secure an improved class of roots as well as continuity of supply. The branches are systematically pruned, while the roots are kept trimmed. In this way, instead of the root developing a straggling growth, it is converted into a bulbous form as well as undergoing distinct improvement in quality.

Digging for briar is an established industry. The finds to be most highly prized are those which externally appear to be covered with a dense growth of small warts. This is the formation producing the bird's-eye marking in the finished pipe, a picturesque effect greatly admired by the discriminating pipe smoker. After the roots have been

trimmed of all superfluous growth they are submitted to a scalding treatment to remove remaining traces of soil which may be clinging thereto, as well as to drive out the sap. They are then dried and re-sorted into a variety of shapes and sizes ready for dispatch to the market. We are large importers of the *bruyère* root, pipe-making having become a flourishing industry in these islands. Upon arrival the briars are spread out to dry naturally, the slower the process the more perfect the resultant material, and then are turned over to the pipe-maker.

Root-digging is carried out with enthusiasm because there is also the possibility of finding a "nugget," as a large well-shaped and excellently figured root might be termed. The majority of the roots are small, weighing but a few ounces. Those recovered from clefts in the rock are generally the more highly prized, since having been stunted in growth, the root has assumed a bulbous form, and is exceedingly hard. Now and again blocks running up to 15 and 20 pounds in weight will be unearthed, to the intense delight of the lucky digger, especially when size is combined with quality. One of the largest roots ever found turned the scale at 56 pounds.

The material entering into the fabrication of the form of pipe known as "the meerschaum" is of far different origin, and is mineral in the strict meaning of the word. For the most part it is obtained from Turkey, although Greece, Spain and Moravia, as well as one or two other corners of the world, furnish certain quantities, but meerschaum of the best quality is to be found in Turkey, the centre of the industry being Asia Minor, particularly the plains of Eskichechir, 250 miles south of Constantinople, where there are apparently inexhaustible deposits of this valuable white earth.

KIMBERLEY DIAMONDS IN THE ROUGH

The masses of crystallised carbon after having been separated from the clay with whic
they are associated.

THE SMOKER'S COMPANION IN ITS RAW CONDITION

A lump of briar root as torn from the ground.

The Search for the Smoker's Friend

It is a strange substance. Its composition, according to the chemical formula, appears to be somewhat formidable, but it is composed of silica, magnesia, and water, or, as it is generally expressed, it is a hydrous silicate of magnesia. It is white or slightly buff in colour and is extremely light, possessing the peculiar property, when dry, of floating upon water. Pieces are often picked up while floating in the Black Sea, having been washed out of the matrix in which they were formed, and it is this circumstance that doubtless gave rise to its curious name. "Meerschaum" is a German word meaning "sea-foam," and the substance was regarded by the ancients as being petrified sea-foam. When one recalls that it is generally found in the shape of pebbles, with a beautifully smooth surface, and when floating upon the sea does resemble sea-foam, while it also possesses the quality of lathering, the nomenclature is appropriate though singularly erroneous.

The principal mines in the Eskichechir district are at Sari-sou, Sepetdje, Gheikli, and Menlou. No restrictions are, or were, placed upon prospecting and working the deposits. Anyone can indulge in meerschaum mining upon the payment of 10d., the cost of a licence. It is difficult to describe the condition of the industry, or the activity with which it is being pursued to-day, owing to the upheaval created by the war, but mining was brisk six years ago according to Turkish standards, several thousand persons finding its recovery highly profitable, the market being firm and with an upward tendency.

The Sari-sou pit was opened about 1880 and the workers dug about 8,000 mines, of which, however, 6,000 had been abandoned by the beginning of this century. The remaining 2,000 mines afforded employment to 4,000 miners for the

accommodation of which 1,000 huts were erected, and they realised the product of their toil once a week. The market was held on Friday, and the whole of the previous six days' accumulation was disposed of each market-day.

Similar stories of bygone activity are to be recorded in connection with the Gheikli and Sepetdje mines, which are in close proximity. At the former place 3,000 pits were opened, but they dwindled down to about 100 active pits. Apparently the practice is to confine operations to shallow working under the individual mining system, a pit being abandoned when the deposit of meerschaum has been exhausted. The Sepetdje mines, about 18 miles to the north-east of Eskichechir, are among the oldest in the country. It is said that the first pits were sunk over a thousand years ago, and they have been worked more or less zealously ever since. Within an area of six miles there are approximately 20,000 pits, but only about 100 of these survive to the present day. This mine is in a more or less settled area, the 500 persons engaged at the mines residing in the surrounding villages.

While meerschaum is mainly employed to satisfy the desires of the smoker it was formerly extracted for other purposes, although what the precise applications were is not exactly known. No doubt appreciable quantities were used for ornament, the material being excellently adapted for carving, while, possibly, it also entered the forgotten arts.

The mine at which work is conducted upon a somewhat more organised, if equally primitive basis, is at Menlou. The number of active mines, however, has sunk appreciably, while the number of men actually employed therein has likewise been reduced to an insignificant number. When the mines were at the height of their prosperity 1,770 pits were under exploitation, engaging over 5,000 workmen, for the most part

Kurds and Persians. The method of working is distinctly crude, machinery of any description being conspicuous by its absence. Menlou, however, as a meerschaum mining centre, is a somewhat important place in official eyes, being the only deposit for which authority was given to win the mineral from the earth. Consequently, there is some attempt at order and system.

The practice is for a foreman or "boss" to peg out the claim. Then he enrols a gang of two to fifteen men, according to the projected scale of operations and his financial standing. A pit is sunk until the miners encounter the red clay indicative of the meerschaum-bearing strata and in which it is found in kidney-shaped and other irregular nodules. The red clay may be found but a few inches below the surface; on the other hand, it may be necessary to burrow down to a depth of 200 feet. Generally speaking it is met at about 70 feet. Once the red clay, or gangue, is reached, a gallery is struck in a horizontal direction following the vein. The gangue is exceedingly hard, and, as the simplest of hand-plied tools are used, progress is painfully slow, averaging only a foot or two a day. As the meerschaum is found in lumps ranging from the size of a walnut to a large apple the prizes are not very attractive, although occasionally a large block will be unearthed.

The miners continue to drive the horizontal gallery indefinitely. Some of them reach for a distance of a quarter of a mile or more from the main shaft. Owing to the fact that the pits are sunk somewhat promiscuously, according to the fancy and discretion of the "boss," and often strike the one vein of red clay, it is by no means uncommon for the underground workings of various mines to meet. The result is that the earth beneath Menlou is honeycombed through

and through by these workings. Mining is continued night and day without cessation, the working face and galleries being lighted by naked petroleum flares. The atmosphere below, as may be imagined, is far from being congenial, and is one in which the self-respecting white miner would decline to labour.

The meerschaum, with portions of clay still adhering, is transferred from the pit to the houses of the miner to be stored until the weekly sale takes place. On the Friday all stocks are brought out and displayed. The merchants of Eskichechir are the purchasers, and their representatives and agents attend the sales, buying the mineral in job lots. The mineral is then transported to Eskichechir, and upon receipt is submitted to a washing and cleaning process, every trace of clay being scraped off, while the irregular pieces are roughly shaped. They are then inspected and graded into four distinct classes according to quality and size. The product is now offered for sale to the European pipe-manufacturers, whose representatives are on the spot, disposal being attended with true Oriental haggling and bargaining. But at last the deal is clinched, and the meerschaum is packed for its consignment to the distant pipe factories. Extreme care has to be observed in packing owing to the fragility of the material. The meerschaum is wrapped in cotton wool, and the inner box is placed within an outer stout packing-case, which is also tightly packed with a suitable medium to prevent shocks and jars being communicated to the contents during transit. The output from the Eskichechir mines ranges from 120 and 130 tons a year. This may not appear to be an impressive production, but when one recalls how extremely light meerschaum is one will realise that even one ton will represent a considerable volume.

When first mined the meerschaum is somewhat soft and inclined to be plastic owing to the presence of water. But upon exposure to the air this water speedily evaporates, leaving the material dry, firm and hard. In the factory, after being roughly sawn to shape, the meerschaum is soaked in water until it has become quite soft. In this form it is distinctly saponaceous, and if rubbed will produce a lather, thus forming a good substitute for soap. Probably this peculiar feature had something to do with the evolution of its name. In the soft form it can be worked very easily, while subsequently, by drying, the requisite degree of hardness is restored. For the guidance of the smoker who takes a keen delight in colouring his meerschaum, it may be remarked that in making his selection he should not choose the pronouncedly white variety. That having a slightly yellow tinge is the best because it will more readily assume that shade of colouring which he considers so eminently artistic. The smoker should also guard against selecting a piece which is very light, since that indicates extreme porosity and inability to take the colour properly. On the other hand, if the pipe be heavy the meerschaum will be too dense to absorb the nicotine. Finally, the smoker should take every precaution to see that he is buying genuine meerschaum. Even this product is not immune from adulteration, while substitution is not unknown.

CHAPTER XIX

Gems and Jewels

THE treasure trove of Nature may be broadly classified. There is that possessing utilitarian value purely and simply, and also that which is essentially decorative and ornamental. While some, notably gold, silver, platinum and antimony, to mention only a few, may be used in both provinces, others are only of value when considered as articles for personal adornment. The list of gems and jewels is somewhat lengthy, but it comprises many stones which to-day are considered as being of minor importance.

Of course, the diamond, to which I have already referred, heads the list from reasons of beauty, scintillation and expense. In comparison with this crystallised carbon all other stones, though of beautiful colourings, and in some cases possessing that quality of ever changing undulating lustre, called *chatoyancy* by the French, appear to be of negligible value. To a certain degree this depression in popularity and value is due to the fickleness of Dame Fashion, the precept concerning the bad name and the dog being equally applicable to precious stones. As a case in point one has only to recall the bad luck of the opal, which, according to superstition, attends the display of this stone.

The scientist, however, has been somewhat responsible for accentuated depreciation of the so-called precious stones. He has reaped greater success concerning synthetic produc-

tion in this field than in connection with the diamond. Sapphires, rubies, and one or two other stones of decorative value are now being produced in the factory, with the result that they are now less prized than formerly, and are appreciably cheaper. Incidentally the effect wrought in connection with the marketing of such stones, as a result of artificial and controlled production, offers a conclusive index as to what will happen when the chemist overcomes the secret of the diamond; and it must not be forgotten that each successive triumph in the synthetic production of jewels is bringing the patient and persevering worker nearer and nearer his goal—the commercial production of the diamond to bring it within the reach of industry. It may seem a hopeless quest, and the synthetic production of the sapphire and the ruby may be declared to have no bearing upon the issue. This is fallacious reasoning, because these two stones and many others, including even the diamond itself, belong to the corundum series, the commonest form of which is the familiar household emery powder.

Nevertheless, despite the antagonistic influences of capricious mode and factory production, certain stones which once ruled high in favour have still a wide vogue. Their distinctive beauty and colouring, as distinct from the quality of *chatoyancy,* render them popular. Among these may be mentioned the sapphire. It is the stone of true "cornflower" blue. The circumstance that this gem has lost little, if any, of its grip, though its popularity is subject to passing moods, was brought home very convincingly in 1908. In that year there ensued a rush to Sapphire Town, the new mining centre, so named from the discovery of this stone, near Anakie, Queensland. Of course, the boom cannot be compared in frenzy or dimensions with a stampede attending

the announcement of the discovery of a new gold field, but it was instructive.

The sapphire field, situate on Retreat Creek, had been known for some years previously. In 1902 a comprehensive report was prepared dealing with the occurrence of the mineral, relating that the stone was to be found over an area of 400 square miles. The field is up-country, lying about 200 miles distant from Rockhampton on the coast, and from six to ten miles from the nearest railway station. For some years, owing to the world-wide slump in sapphires and the droughty conditions of the sapphire-bearing country, the deposits were worked only intermittently and upon a small scale. Those who troubled to prospect for the stones were sheep-shearers and station hands, who, their seasonal work completed, passed the time scratching for the jewels. They were supported by disappointed gold seekers, who eked out an existence sapphire hunting in the vain hope that they might strike gold, or some other valuable mineral.

To convey an idea of the indifferent manner in which mining was conducted it may be mentioned that it was the practice of the miners to make up their parcels of "finds" and to dispatch them to the coast at intervals. In these parcels they enclosed any other stones, of the nature of which they were ignorant, in the hope that they might prove of some market value. All was grist to the mill of the miner in those days. One day the State geologist, animated by curiosity, persuaded one of the miners to open a parcel which he had hastily packed for such transmission. The expert wanted to investigate the nature of the doubtful stones. Imagine his surprise, upon examining the contents, to find a beautiful colourless diamond weighing 1½ carat. The miner did not know what it was and was content to trust

to luck, or honesty, upon the part of the recipient. The geologist was prepared for such a surprise, being thoroughly conversant with the district and the character of the different gems which it should be able to yield. Needless to say, doubtful stones were ever after examined somewhat more closely, and the more than doubtful specimens carefully placed in safety.

Suddenly the Australian sapphire was declared by the world of precious stone dealers to be uncommonly fine. A demand for the gem instantly ensued, and this provoked the rush. In 1905 there were only 75 miners in undisputed possession of the field; two years later the population had grown to 850. Sapphire Town was typically a boom creation. There was only one street, lined with shacks, shanties and tents—extemporised inexpensive dwellings which did not involve heavy financial outlay, lest the venture might suddenly collapse.

Winning the gem is carried out along the crudest and cheapest lines. Some of the prospectors merely turn over the surface of the pay-dirt on their claims, others dig from 20 to 30 feet down. Being a mixture of sand and gravel, the pay-dirt is easy to work. Screening allows all the fine sand to fall away. Then the sieve is plunged into a tub of water, given a few smart twists and jerks, which brings the heavier material to the centre, the escaping water carrying away the soft earth which it dissolves. The sieve is then turned upside-down and the stones picked out by hand.

In the lower levels the pay-dirt is a trifle more resistant, being associated with clay. In this instance more thorough and careful washing is necessary. Long troughs contrived from hollowed out tree trunks are charged with the pay-dirt

procuring water in the opal-bearing districts to allow mining to be conducted upon a sufficiently attractive scale. In New South Wales the outlook is somewhat brighter, although here again the water difficulty sometimes becomes disconcerting. Fields have been prospected and have been declared highly promising, but only so long as an adequate supply of water is assured. As the centres in question are somewhat off the beaten track, the probability of water being carried thereto is a trifle remote at the moment. Possibly it would prove profitable to bore for water, since an artesian supply would meet the situation very neatly.

The finest grade of this gem is obtained on the Wilcannia field, some good stones having been obtained at a depth of 50 feet. It has been found that as the level is lowered the stone extracted improves in quality, as well as becoming more regular in its formation. On one claim a fine block was obtained, realising over £3,000. Within the course of seventeen years opals to the value of a round £1,000,000 were taken out of the fields of New South Wales, the year 1902 recording the best return with an output worth £140,000. Here again variation in quality, combined with fluctuating price, is a disturbing factor, and this uncertainty exercises a repressive effect upon mining activity, the toilers naturally preferring to work for some other mineral which rules steadier upon the world's markets. Some of the opal has fetched only 10s. an ounce; on the other hand, the super-excellent specimens will command £70 per ounce, and that in the rough. Taking the regular supplies of average quality, the price fluctuates between £5 and £20 an ounce. This trade was almost exclusively in the hands of the Germans, the opal finding a ready sale in Germany. Consequently the outbreak of war and the immediate extinction of the most

remunerative market played sad havoc with the industry. New South Wales, however, holds a somewhat peculiar position. It is said to possess the only field in the world in which the "black" opal, a most highly prized gem, is to be found, one weighing 6½ carats, which was found on the Wallangulla field in 1910, realising £102.

In so far as the various gems are concerned, the new countries find it extremely difficult to compete with the output from other places, which, from being worked consistently for years, have secured a complete and peculiar grip in the gem-buying world's favour. Thus the Australian opal is brought into conflict with the Mexican product, which is systematically mined at Queretaro. Again, Siam has come to be regarded as the world's great treasure-house in regard to gems, this wealth being won from what is frequently described as the most wonderful 100 miles of gem-bearing ground in the world. Doubtless the Eastern association with the industry exercises considerable influence upon popular selection, which is very readily impressed. There is an atmosphere of romance, glamour and mysticism about that corner of Asia, which is entirely absent from the newer countries developed along prosaic, matter-of-fact, commercial lines. Thus the garnet, topaz, amethyst, agates and rubies are found in many of the latest countries to be opened up, but, rightly or wrongly, the product is not regarded with that appreciation extended to similar stones derived from other and older countries where gem-working has been followed possibly for centuries. One point is deserving of emphasis. In the established gem-mining countries the standard of quality is distinctly high. Only the finest stones ever reach the market; those which would satisfy the orthodox prospector and be sent to market would probably meet with

rejection by the severely critical native. He has been raised in an exacting school; he appears to be endowed with the hereditary capacity to select only stone utterly without flaw, irreproachable in colour, and other essential characteristics, probably from association with gems which have been persistently and consistently worked in his country for centuries. Then he is able to pursue the search for jewels along different lines. He is his own master, his standard of living is low, his method of working is ridiculously cheap, and he is assured of his market.

If one desire confirmation of this peculiar law governing the gem kingdom one need only turn to the turquoise. This gem first claimed attention in the dim distant past because of its alleged medicinal value. Among the earliest races of this earth it was considered only from the therapeutic point of view; it was not until a later date that its artistic and ornamental properties met with recognition. It constituted the ingredient of a host of remedies. Then it became invested with strange faith. Worn as a ring, it was regarded as bringing happiness of mind to the wearer and to be a miraculous protection against bites, stings and attacks by man, beast, insect and the blind forces of Nature. Its very name signifies "victorious." This mystic power was by no means confined to the Persians, among whom it was born and carried to such a degree as to become the vogue, but it spread through India, the East, and even to the American continent. The Pueblo Indians and the Apaches set an exceptionally high value upon this stone. To lose a turquoise is to meet disaster. The medicine men use it in all their strange ceremonials, no doubt a survival of similar practice among the ancient Aztecs. In the British Museum is a remarkable Aztec ceremonial mask, comprising

a human skull inlaid with turquoise and other decorative stones, representing the god Tezcatlipoca. From the fact that the rear of the skull is so cut away as to permit it to be set in position upon the head, it is surmised that this strange mask was either fitted over the face of an important idol, or was used by the priest representing some important native deity upon great ceremonial occasions. However, the fact that this strange turquoise worship originated in Persia has invested the gem mined in that country with paramount importance, although it is to be found in many other parts of the world.

Yet in the land of the turquoise, as one might appropriately call Persia, the mining of this gem, which is carried on to this day, follows the most primitive lines. It is won from the heart of the hills. A tunnel is driven into the treasure-house, which from the exterior is certainly unprepossessing in the general setting of sterility which prevails. The gallery, neither driven in straight nor level, and barely affording head room, leads to the working face, which is somewhat more spacious. Here the turquoise-bearing ground is mined by natives equipped with hammer and chisel, in the fitful flicker cast by lamps as primitive as the workings and methods themselves. The native miners tear the blue earth out in rough blocks, which are broken to a convenient size, packed in bags and carried by boys to the surface, thence to the village, where the ground is passed through an equally simple milling treatment to recover the stones. Gold panning by hand is crude, but it is not more crude than the process for winning the turquoise as practised in Persia, and which has probably been handed down from father to son from the long distant past without suffering the slightest modification of detail.

The earth-laden bags are discharged into a shallow pan with water in which the boys paddle, and in so doing crush or puddle the earth, being encouraged in the process by overseers equipped with formidable canes. As the earth is broken up and dissolved it is run off, fresh water being added from time to time until the "boss" considers that the work has been carried sufficiently far. The spoil in the pan is then examined, and the whole, while still wet, is packed into bags and dispatched to town to be submitted to the merchants and agents for purchase. But even the unsophisticated Persian native miner is not so ignorant as he may appear. Packing the stones and mud in the wet condition may increase the weight of the load to be carried, but it improves the value of the gems. By being kept moist they retain that glorious blue colouring so characteristic of the gem. On the other hand, if they are permitted to dry they turn an anæmic and unattractive green. Doubtless the white man, with his wonderful mechanical handmaids, would essay to introduce modern methods, but it is a point for argument whether he would succeed to the degree attained by the indigenous worker. Not only does the latter ensure his stones reaching the market in the primest condition, but the somewhat primitive method of working which is followed serves to keep supply to the limited level of demand, with the result that prices do not fluctuate widely, and this, after all, is the most vital factor.

As a gem the ruby has always commanded distinct attention, its deep rich colouring being responsible for the universal admiration it provokes. Although it is generally described as being fourth in importance in the scale of jewels and gems, yet the appearance of a true, fully-blooded stone is so rare as to render a gem of four carats or more in weight

to be commercially more valuable than the finest diamond of equal weight. From which it is only natural to remark that there are rubies *and rubies*.

The great ruby-producing centre of to-day is Burmah. Precisely when the mining for the precious red stone was first essayed in Farther India is somewhat obscure, but for nearly three hundred years the mines of Mogok and Kyatpyin, whence the finest pigeon-blood rubies are obtained, were regarded as the personal property of the reigning Burmese monarch. All stones which exceeded 500 rupees in value became automatically the property of the Crown. The prevalence of such a system reacted against the market, because, if a native miner happened to alight upon a large and valuable specimen he was tempted to break it to pieces, to bring each of the fragments beneath the Crown property mark.

With the annexation of the country by the British the question of mining the rubies upon a modern basis promptly arose. In due course, after considerably prolonged negotiations, a British company, the Burma Ruby Mines, Limited, of London, were granted the sole right to mine for rubies at any place where they might be found, and which was not already being worked by natives, the concession being granted for a term of years at a fixed annual rental, which to-day is 200,000 rupees (about £16,700), plus 30 per cent. of the net profits and a further financial contingency, so that the Indian Government has a heavy stake in the enterprise.

The area of the Stone Tract, as the ruby-bearing country is called, is about 400 square miles, the centre being the village, or local town, of Mogok. When the mining engineer first arrived upon the scene in 1889 he was

confronted with as hopeless an outlook as can be conceived. The only means of access was a cart-road, 60 miles long, leading from the river Irrawaddy, which was only passable in fine weather. All the most promising areas were in possession of the natives, which he was not at liberty to exploit under the terms of the concession. Outside these patches was nought but dense jungle, void of tracks and shelter for Europeans, with food supplies uncertain and indifferent. Moreover, he had to evolve his own ways and means to win the stones, since the conditions were totally dissimilar from those obtaining in any other part of the world.

Despite these handicaps a remarkable industry has been established, although it has been a costly and tedious process. The Mogok Valley was ultimately abandoned, the engineer transferring his plant and staff to the Kyatpyin Valley, eight miles away, to commence operations upon a conical peak which the natives called Pingutaung, which translated means the Hill of Spiders, honeycombed with caves packed, according to the Burmese tradition, with the byon which carries the precious pigeon-blood ruby. On the very first day one of the finest rubies ever found was secured, and this discovery was regarded as a happy augury. But how fickle is Fortune! As events proved, this appeared to be the only prize imprisoned in the hill, for the harvest reaped from washing and sifting the earth composing that peak failed to yield sufficient stones to defray the cost of the laborious work.

So another move was made, this time to the Tagoung-nandiag Valley, a mile away. Here a complete plant was laid down, the engineer having determined to carry out his attack upon the supposedly rich ruby-bearing ground upon a big

scale. It was a bold move; but its very audacity brought success. The company, which had experienced many disheartening checks, turned the corner, and in the process the largest and most valuable stone was found. In the rough it weighed 18½ carats, which was reduced to 11 carats by cutting, but it realised £7,000, which serves to illustrate the price which a prime ruby is able to command. Unfortunately, the valley being somewhat small, and the methods of mining now introduced being extremely voracious, it was exhausted within two years, and it became necessary to move to an adjoining ravine.

Nevertheless, the experience attained, especially with the new mining system, was exceedingly productive. The results achieved pointed to the fact that it might be profitable to return to the formerly abandoned Mogok area, and embark upon operations upon a similar big scale. This was done, and instant success was recorded. From the Shwebontha mine alone, during the period January, 1895, to February, 1904, a matter of nine years, 4,820,000 truck loads of pay-dirt, valued at 7,280,000 rupees, or over £485,000, were removed at a cost of 3,000,000 rupees, or £200,000.

The method of mining adopted is interesting. A pit 10 feet square is sunk to a depth of 25 feet, and in the bottom a pump is placed to cope with the water draining into this shallow well. The soil around the pit is then excavated and trucked, the pit forming the starting point. In this way a huge open crater or working is made, the wall being pushed outwards until the water accumulating exceeds the capacity of the pump. The pit is then lowered and further pumps installed to keep the water down.

The pay-dirt, or byon, after being loaded into the trucks, is carried to the washing plant, where it is dumped into

screens and subjected to a disintegrating process. This breaks up the byon, allows the riddled earth to fall through the perforations into the washing pans, which are 14 feet in diameter. Here it is combined with water, to be churned into thick mud by revolving arms provided with teeth. The lighter soil is run off into a safety pan, leaving a deposit of heavy gravel, with which the gems are associated. The process, it will be seen, is really an application of our old and crude gold-panning method reduced to mechanical scientific principles. So effective is the panning that 2,000 truck loads of byon are reduced to 10 trucks of concentrates within ten hours, and the process is so efficient that barely one per cent. of stones escape from the mill into the safety pan. Further mechanical screening takes place, together with other treatment, until at last the gems remain in a sieve with only a small proportion of gravel. This sieve is turned upside down, and the rubies, being at the top, are picked out by hand. The finest stones are recovered by skilled English sorters, and the remainder graded into fourteen different qualities by natives, who have become exceedingly expert in this work. Only the finest stones are dispatched to London; the inferior grades are sold under an interesting auction system to natives upon the spot. Other gem stones belonging to the ruby group, such as garnets, fragments of tourmaline, beryl, crystal and corundum are frequently found. The greater part, being of inferior quality, likewise finds a local sale. The accumulation, however, is appreciable, and an idea of its low value may be gathered from the fact that such gems, aggregating 500,000 carats, are often sold during the month to native buyers for £180 to £200. How this vast quantity is absorbed no one appears to know. Probably it enters into the manufacture of cheap

native jewellery, a vast quantity of which is no doubt passed off by the wily native upon unsuspecting visitors and travellers, who so freely purchase specimens of Eastern arts and crafts and Oriental bric-à-brac, attracted thereto by the glitter of the gems.

Although the modern machinery installed by the imaginative engineer is devouring the Burmese ruby-bearing ground at an amazing speed, no apprehensions need be entertained of the country's store of pigeon blood rubies petering out for many, many years to come. Prospecting is still being actively pursued throughout the 400 square miles of the leased concession. New areas are steadily being discovered and ear-marked for future treatment. From time to time the engineer makes a dip into Nature's deep lucky tub, to encounter a startling though eminently gratifying surprise. One of the greatest of these was made as recently as July, 1919, when the company, which has been persistently working this country for thirty years, alighted upon its largest, finest and most valuable stone. It is a magnificent gem, weighing in the rough 42 carats. It is a ruby among rubies, and its value is quite problematical. It is stated that £40,000 was offered for the stone directly the news of its discovery was noised abroad—and refused. But one thing is certain. It will fetch much more than would a diamond of equal size, which serves to prove that even to-day a ruby of the finest water is quite capable of holding its own against the scintillating crystallised carbon.

CHAPTER XX

Mineral Maids-of-all-Work

IN our unstinted admiration of the rare, valuable, artistic and noble treasures to be found in the wonderful and inexhaustible Aladdin's Cave of Nature we are apt to overlook the more humble classes of treasure trove—the drudges of commerce, the mineral maids-of-all-work which, entering so intimately and so extensively as they do into our complex everyday life, escape the true measure of recognition which they deserve. Yet how should we be able to get along without them? If there were no brick and kindred organic constructional materials, either won in the pure form from the earth or prepared from the careful blending of various substances to be obtained only by the expenditure of effort with shovel, pickaxe, explosive or mechanical devices in infinite wonderful variety, all industrial activity would be brought to a standstill. In that event there would be no necessity for us to dip into Nature's lucky-bag for those other rarer and more valuable prizes, to secure which we are so ready to incur privation, hardship and grave risks, because we should be unable to turn them to account either for utilitarian or ornamental uses.

It is hopeless to attempt to specify all the products which of grim necessity must be won from the earth to keep the mills of industry running. Their diversity is astounding, their number infinite. If a handful of soil be examined

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QUARRYING MARBLE IN SOUTH AFRICA

Chalk or limestone is probably one of the commonest materials in Britain. Our cliffs, hills and ridges are huge stretches of this material. It is fortunate for us that such happens to be the case. Were our resources of these earths meagre, as they are in some parts of the world, we should find ourselves in a very awkward position. Limestone is the "one-horse shay" of chemistry, and Britain has a wonderful chemical industry; it is the backbone of the vast alkali trade. Subjected to heat, the crude calcium carbonate, as it is technically called, undergoes decomposition, forming quicklime, and in this condition is virtually infusible, a property which renders it available for numerous commercial applications. It provides us with the limelight, the brilliant illumination indispensable to the modern stage. Without it we should be confronted with an interesting problem as to how to melt platinum, which demands a temperature capable of driving the mercury in the thermometer up to 3,420 degrees Fahrenheit. Crucibles formed of quicklime are essential for the purpose. Is it surprising, therefore, to find the mining for lime an extremely active and widespread industry? In the Peak district mountains of limestone are being steadily devoured and shipped to hives of industry to keep the wheels of commerce revolving steadily.

But our buildings would be of little use unless roofed and provided with windows. Roofing materials are varied, but those in greatest request are of mineral origin. Tiles are popular, their preparation being broadly similar to the fabrication of bricks, while slates have also an extensive vogue. The latter are won for the most part from huge crater-like workings in Wales. The slate is a peculiarly suitable material for roofing, while it is also in demand in the electrical industry, owing to its insulating properties.

It can be split into thin sheets, and possesses striking weather resisting properties. It is quarried in the open workings in the usual manner, being torn out in huge slabs, which are transferred to the adjacent works to be split, trimmed and classified. The pits to-day, as a result of steady working for year after year, have become wide, yawning crevasses. Here and there in the slate mine will be found projecting masses of rock, which the workers sedulously avoid. These are faults; they possess little or no slate and are an incubus to the working. At intervals these gigantic projections are removed by the simple expedient of blowing them to smithereens, and when one of these dykes is touched off with a charge of gunpowder, running perhaps into 135,000 lbs. for the single blast, the volcano appearance of the crater which the quarry presents is momentarily enhanced. A charge of this magnitude is capable of producing a decided rumpus, culminating possibly in a strange alteration in the configuration of the mountain.

In so far as the glass is concerned, the demand upon the materials forming the crust of this earth for its fabrication is far-reaching. When we look through a large sheet of beautiful transparent glass enclosing a shop window, or possibly marvel at the wonderful work performed by an optical instrument, it seems incredible at first sight that such an extraordinary transparent substance should really be wrought from opaque materials. Yet glass, which may be shivered so readily, is in reality a mineral. It is wrought from metallic and non-metallic materials, and the transparent effect which is ultimately obtained is due to the chemical reactions and intense heat incidental to the manufacturing process. While minerals are so freely employed, they are not necessarily used in the pure state. The majority are

chemical compounds prepared to meet the glass makers' requirements. Yet to prepare these essential chemical compounds the chemist must be provided with the various raw materials, which have to be drawn from the earth.

Optical glass undoubtedly makes the heaviest demand upon the communities specialising in winning the necessary treasures from the earth, inasmuch as it represents the highest level of the craft. To indicate the varied exacting demand for materials entering into the formation of the earth's crust to furnish a product which will enable the astronomer to bring the heavenly bodies sufficiently close to his eye to enable details to be studied, to allow the photographer to secure sun-pictures in the thousandth or less part of a second, and to allow the structure of the elements to be investigated by the aid of the spectrum, to mention only three of the thousand and one uses for which optical glass is required, I am able to present a little list which offers interesting reading. For this information I am indebted to the courtesy of Messrs. Chance Brothers, Limited, of Smethwick, who easily rank as the world's leaders in this highly specialised branch of industry. This list is not complete, because naturally in the preparation of optical glass there are secrets as in every other ramification of endeavour, but it suffices to bring home the tax upon certain phases of mining activity. This list is as follows:—

1 Sand, the best white obtainable.
2 Precipitated chalk.
3 Carbonate of soda.
4 Carbonate of potash.
5 Nitrate of soda.
6 Nitrate of potash.

7 Carbonate of barium.
8 Nitrate of barium.
9 Boric acid.
10 Borax.
11 Oxide of zinc.
12 Carbonate of zinc.
13 Oxides of lead.
14 Oxide of antimony.
15 Oxide of arsenic.
16 Hydrate of alumina.

Such are the materials, but as already stated, many are not prepared by the glass maker himself. It is work for the mills of chemistry, and so the manufacturer merely indicates his requirements, which the chemist must fulfil, and to the degree of purity which is imposed. However, by analysing the foregoing list it is possible to ascertain the basic mineral, and then we can see what a world-wide call the glass maker has for materials to enable him to conduct his craft.

Sand is the chief constituent of all glass. It enters into the making of the bottle, the material for glazing cheap pictures and greenhouses, and the finest plate quality, as much as in the preparation of optical glass. But the maker of the last-named is necessarily somewhat hypercritical. His sand must be the very finest white obtainable, and the world is rigorously ransacked to meet his exacting needs. Up to the present the pits of Fontainebleau, France, have been found to furnish the finest grades of this constituent, and this naturally forms the sheet-anchor of supply. During the war, owing to the huge demands imposed upon our optical glass making industry, and the difficulty encountered

in obtaining sufficient supplies from the French source, we were forced to investigate possible domestic sources. As a result we discovered promising beds of white sand, having the requisite high silica content, at Leighton, Aylesbury, and Lynn, as well as at Hastings, in England, Muldron in Scotland, and Muckish Mountain, County Donegal, in Ireland. But the French sand holds the palm in point of purity and uniformity in size of the grains.

So far as the precipitated chalk is concerned, we are quite equal to the occasion, because this commodity is merely our old friend limestone, or calcium carbonate in a certain prepared form. It enters extensively into the manufacture of glass, and so its free occurrence at home is distinctly fortunate for us. The crude limestone is subjected to an elaborate treatment to eliminate all impurities, optical glass demanding the very highest grade of carbonate of calcium that the chemist is able to offer.

Sodium carbonate, another freely used constituent, is prepared from one of the most familiar substances won from the earth—common salt—to which I have referred in a previous chapter. For the cheaper grades of optical glass sodium sulphate is used, and this likewise is prepared from common salt, the last-named, as is well known, forming the base of nearly all sodium compounds.

One ingredient without which glass cannot be made is potash. It is used in the carbonate form. Formerly the material was extracted from wood ashes, with which the chemical is associated in a minute quantity. But when the extensive underground deposits of this mineral at Stassfurt, in Germany, with which I cannot deal in this chapter, were brought into productivity, this became the storehouse, upon the stocks of which the world drew for

its needs. At Stassfurt it is mined in the form of a salt—chloride of potash—from which the carbonate is manufactured. With the outbreak of war this source was cut off naturally. Again we had to turn round to discover what we could induce home resources to contribute. Certain felspars carry a proportion of potash, and accordingly it was decided to submit this natural product to treatment with a view to extracting the requisite commodity. But the working of iron also releases considerable quantities of potash which are associated with the ore, and which were permitted to escape through the flues of the blast furnaces. Accordingly ways and means of trapping this valuable commodity in its flight were devised, and in this way we succeeded in securing all the potash the glass making industry required, so that we were not broken by the interruption in supplies from Stassfurt, as undoubtedly the powerful German monopoly anticipated would be the case.

The barium (baryta) constituents may not be so familiar to the average reader. These are made from a native stone known as witherite. This is an impure carbonate. It may also be prepared from the sulphate of barium—heavy spar—but the natural stone is not used in the fabrication of optical glass. It is essential that the compound should be of extreme purity, hence the preference to extend the treatment of the raw material to the chemist.

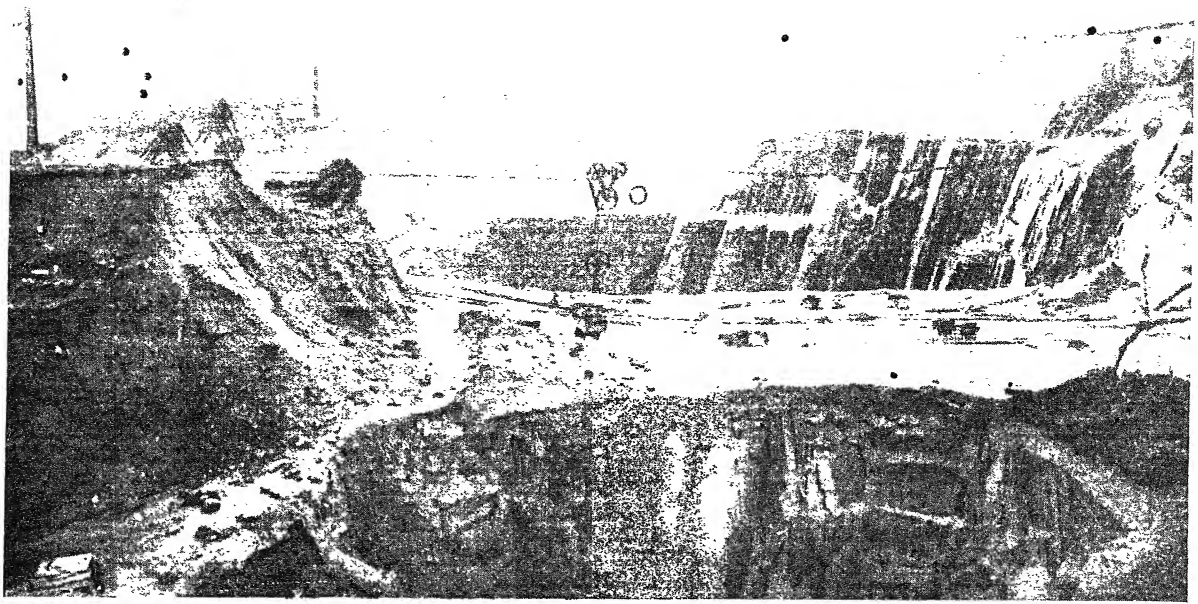
The boric acid and borax are derived from two widely separated parts of the world. The first-named is drawn for the most part from the volcanic districts of Tuscany, while the borax is secured from sinister Death Valley, California. The lead used chiefly in the form of oxides, of which the most common are red lead and litharge, is prepared from the mineral. Manganese, which is used by all glass

makers, occurs freely in certain parts of the world, notably India and the United States. So far as the alumina is concerned, this is extracted from felspar. The hydrate of alumina which enters into the manufacture of optical glass is a prepared product, and, of course, it is requisite to secure the alumina first, which gives rise to the mining of the clay and the felspars.

While, as previously pointed out, it is impossible to narrate all the materials, the bases of which have to be won from the earth, entering into the manufacture of glass, the foregoing will suffice to prove that it really extends support to very many branches of mining. For instance, digging for sand has developed into an imposing industry. In pre-war days we imported over 300,000 tons of this basic material from Belgium, Holland and France, but to-day, for the cheaper grades of glass, such as bottles, native deposits are being opened up, one such large "bank" of suitable sand having been found in the Isle of Thanet.

To mine sand may sound somewhat curious, but, as a matter of fact, it constitutes a thriving and extensive industry in itself. Sand enters into so many branches of industry, and each ramification demands a specific grade and class of material. It is in heavy request for the lining of steel furnace hearths, while it is indispensable to moulding of iron, steel, and other metals. The moulds are fashioned from this material, that best adapted to the purpose being known as "moulding sand," and it is imperative that it should be possessed of certain characteristics to ensure the moulding of the molten metal being efficiently carried out.

How would the pottery and ceramic industries thrive without adequate supplies of various materials of distinctive characteristics torn from the earth? Of these probably the



SLATE QUARRYING IN WALES

The demand for slate has established a flourishing industry in the Principality. The above view shows the open workings at the Penyrorsedd Quarries and the overhead cableways, whereby the slabs of mineral are conveyed to the cutting and trimming mills.

most important is kaolin, or, as it is more familiarly known, china clay. The material itself is widely distributed, but the deposits of pure white clay are relatively few. This clay represents the results by natural agency of the decomposition of the felspar in granite rock, and as a rule it is associated with iron impurities in sufficient quantity to change the colour of the clay during the firing process. On the other hand, the china clay will retain its pure white colour in all circumstances. It is not affected by the heat in the kiln. Consequently it is indispensable to the fabrication of porcelain and white china.

It does not receive its distinctive name from its use in the china-making industry, as might naturally be supposed, but from the fact that it was first found and used in China. Its technical name is a Chinese word, being the contemporary version of Kaoling, meaning high ridge, constituting the name of the hills in which it occurs in the centre of the Chinese porcelain manufacturing district, and to feed which industry it is consistently mined. It was exported to this country from the East up to about 150 years ago, when prospecting revealed the occurrence of immense beds of a native product, equal in every respect to that mined in China, in the St. Austell district of Cornwall. To-day the mining of this clay constitutes a prominent industry in the south-western corner of England, being the only place in the country where the treasure is found. The demand is heavy, the output from eighteen mines in the Cornish and Devon districts being about 500,000 tons per year. But the article is mined not only to feed British industries; its high quality has been responsible for a foreign demand, only a few other beds which are able to compare therewith in quality having been found in other parts of the world. In addition to fur-

nishing an ingredient for the porcelain industry a certain proportion is absorbed by the paper-making trade for weighting certain papers, notably those used for fine art illustration.

The necessity for certain countries to depend upon China to a large degree for such a commodity is paralleled by another example of isolated industry on behalf of the vast porcelain and allied industries. At Ivitgut in Greenland is a valuable mine, the product obtained from which is known as chryolite. It is situate in one of the most inaccessible and uncongenial corners of the world, far off the beaten tracks of commerce. The shipping season is extremely brief; boats call only at rare intervals. The whole of the output from the mines is exported, since obviously the climatic conditions are not favourable to the establishment of an industry upon the spot. In that cold clime mining is indeed beset with privations and discomforts, but it suffices to prove to what lengths, notwithstanding the forbidding character of the outlook and situation, the prospector and mining expert will push their way to keep the chariot of industry moving.

The prospector indeed knows no frontiers. He penetrates the countries of perpetual snow in search for mineral treasure; ploughs the heart of the fever-ridden jungle upon the Equator; willingly accepts a lively tussle with the blind forces of Nature; bares the wealth lying in the mouths of extinct volcanoes, and does not hesitate to push into their smoking and burning crests when the occasion demands or treasure is to be won. From these smoking chimneys leading to the earth's internal fires he is winning sulphur. Another material which has been found eminently adapted for certain purposes, notably cleaning and polishing, is also derived from the precincts of the volcano, to wit, pumice stone. This,

as is well known, is the light lava thrown out by these spouting natural fires, and which has cooled and solidified. From its soft abrasive properties when reduced to the powdered form it is an excellent grinding and dull polishing agent, especially of wood.

Opposed in character to the pumice stone in regard to abrasive characteristic is corundum. It is heavy and remarkably hard, being only slightly inferior in this respect to the diamond. In India it has been used since time immemorial by the native lapidaries in cutting and polishing gems and stones, supplies thereof being drawn from indigenous deposits which are somewhat rich. The most familiar form in which corundum is used in Britain is emery paper, emery being a member of this family. But during late years native corundum has been somewhat under a cloud, the persevering electro-metallurgist having succeeded in producing a synthetic material in his electric furnace, which is so similar to the native crystal as to have been endowed with a similar name—carborundum. This now seriously disputes with the emery for industrial recognition as an abrasive in the metal-working trades.

The artist does not hesitate to draw upon the inorganic possessions of Mother Earth to satisfy his peculiar requirements. Pigments are obtained from ochres, deposits of which are freely scattered, while iron oxide, another frequently recurring substance, is also able to contribute to the ochre supply. The metallic element cadmium, a soft bluish white metal won during the manufacture of zinc, when combined with hydrogen and sulphur, gives a bright yellow colouring matter, the gradation of tone varying according to the acidity of the solution used to bring about its precipitation. This metal, it may also be mentioned, enters into the

art of electro-plating, being combined with the silver to form an alloy.

Reverting to sand once more the presence of silica has enabled many striking manufacturing achievements to be attained during the past few years. The base element, silicon, is one of the most prolific and common materials to be found, as I have already pointed out. The perfection of the electric furnace has opened many new doors to its profitable employment. This is the raw material which enters into the fabrication of that glass used for the preparation of acid and boiling solutions in the laboratory, and even the amateur photographer's red lamp. Such glass may be subjected to the most violent extremes of temperature without breaking. This quartz glass, as it is called, may be heated to a red heat in the blowpipe flame and instantly plunged into cold water and show no ill-effects of the drastic action. Ordinary glass subjected to such violent treatment would be shattered. But it is incumbent that the silica employed should be absolutely pure; the presence of the slightest deleterious substance, while possibly not affecting its transparency, would be adequate to destroy its heat-resisting qualities.

The resort which is now made to extremely high temperatures has also demanded the recovery of raw materials from the earth capable of putting up a stern resistance to the hottest heat. This in turn has prompted more active prospecting for earths of various characters capable of being fashioned into firebricks wherewith to line the furnaces. These materials are described as being of a refractory nature, and there are many which have been found to correspond with the strict interpretation of this term. Among the substances mined to this end are quartz

magnesite, dolomite or magnesian limestone, fused alumina, bauxite, cromite and carbon. Each has its distinctive feature and, to a greater or lesser degree, well-defined sphere of application. According to the Deputy Controller of Iron and Steel Production this range of industry forged ahead in Britain with leaps and bounds during the period of war, the average output exceeding 2,400,000 tons, sufficient to furnish 720,000,000 refractory bricks, during the year. From the recital of these figures some idea of the call upon the mining facilities of this country, in this one field alone which is somewhat privileged, may be gathered. We doubled our production of silica bricks, notching 132,000,000 bricks a year, while the magnesite bricks, which was an unknown range of endeavour in these islands previous to 1914, ran up to approximately 6,000,000 a year.

Before leaving the stones proper, it is opportune to point out that the printing industry imposes a call upon the prospector and miner. The lithographic art is dependent upon a certain grade of stone, although aluminium plates are entering Senefelder's art. Germany held the world-wide monopoly in this industry, the ideal stone, or so it was generally regarded, being a feature of that country. British printers bought about 10,000 tons during the course of a year. But Somerset is able to contribute a stone comparing in all essential virtues with the German article, and the mining of this product has now become established.

We are apt to despise clay, but, as a matter of fact, this much maligned plastic constituent of the earth's crust has given birth to a wonderfully successful and rapidly expanding industry. For years metal workers and users were searching for a metal possessing the primary factor of lightness. The chemist and engineer set to work, and found that from a

special kind of clay, which is freely distributed, a light silvery metal might be obtained. This is aluminium, having a third of the weight of steel, and which, while of far-reaching utility in its direct form, is far more valuable for the preparation of certain alloys, giving an enhanced degree of strength with no appreciable, if any difference, in weight. Bauxite mining in France speedily developed into a big industry. The clay was found in thick beds and readily to be excavated from shelves or terraces. Open working is practised, the clay being transferred by the conventional handling appliances to the electrical plant where, by the process of electrolysis, in which the material drawn from the mines of Greenland—cryolite—plays a prominent part, the metal is won.

Another clay which is productive of a commercial commodity, and which from its greasy touch recalls talc, is fuller's earth. So far as this country is concerned its distribution is somewhat local, the deposit in Somerset being the most important, the vein of distinctive rock, of a marly nature, being about 25 feet in thickness, although it is worked in the eastern corner of Surrey. The rock is capable of being ground to a very fine powder, and it receives its name, not from its discoverer as might be conceived, but from its peculiar property—bleaching, or as it is technically called, fulling wool. It is an excellent grease absorber, and for this reason is used to a certain extent in toilet preparations, although in this field it is being displaced by talc. It is also employed as a filler in the paper-making industry, while it serves a similar purpose in the manufacture of soap.

Another useful earth is gypsum, the most familiar marketable form of which is plaster of paris, for which purpose it has to be calcined, and alabaster. This belongs

to our extensive limestone family, and during the past few years its recovery has been pursued with enhanced vigour, owing to the widening of its field of application. In the ground crude form it enters into the manufacture of paints and the Portland cement manufacturing industry, being useful in the last-named because it is able to retard the setting of the mortar. In the plaster of paris form it fulfils many useful purposes, among these being the preparation of wall and dental plasters. Like asbestos it is fire resisting, and so is being utilised as a building material, being combined with fibrous substance to facilitate fashioning of building blocks. This material is found in the form of large crystals and a floury earth known as "copi." A certain quantity is also utilised for fertilising purposes. It is widely distributed throughout the world, but its exploitation has always been relatively restricted. Now that further uses are being discovered an impetus has been imparted to mining activity. In the vicinity of Hudson Bay there are vast deposits, but as yet they are too remote from the highways of communication and centres of consumption to be worked. Australia has also a practically inexhaustible deposit in the Western State.

Among the many substances in request in the textile trades is alum, although to the average individual it will be more familiar as a remedy for certain of the ills to which flesh is heir. It is freely found throughout the world, but at Bulladelah, New South Wales, exists what might almost be described as a freak of Nature in this connection. It is described as the most remarkable alum deposit in the world. Practically the whole of a low-lying ridge, according to the prospects conducted, is composed of alunite, the distinctive crude substance, the alum content of which

averages 80 per cent. The earth is quarried and shipped to this country, it having been found that the subsequent treatment can be conducted more cheaply here than upon the Australian continent. South Australia is also endowed with a large deposit of this mineral, the beds being within a few miles of Adelaide. This alunite is said to be richer in the essential constituents than that derived from any other known source.

But one of the most novel earths to be used commercially is that composed of the skeletons or shells of minute organisms, which we generally describe as diatoms, and which, under the microscope, are revealed in a bewildering variety of beautiful forms. In some parts of the world these deposits are so dense as to present a thick vein or bank, often of remarkable purity. For the most part the composition, according to analysis, is silica. These extremely small skeletons and shells, in this consolidated form, are known variously as Kieselguhr, diatomite, infusorial earth or tripolite. As might be imagined the substance is highly porous, while it has excellent non-conducting qualities. Its porous nature renders it eminently suitable for filtering water, the advantage of diatomite over other familiar mediums such as charcoal in this direction being that the porosity of the substance allows the water to pass through at once, and almost at the same pressure as it enters the filter. But the passages are so extremely minute as to bring about the complete arrest of all organic impurities suspended in the liquid.

This earth is also used as a base for the manufacture of ultramarine, while more recently it has been utilised for making insulating bricks and tiles to prevent losses of heat through radiation. But its greatest field of application is

in connection with the manufacture of dynamite. As is well known, nitro-glycerine is one of the most powerful explosive agents used, but unfortunately it is dangerous to handle. It explodes at a relatively low temperature. This susceptibility induced Nobel to embark upon a long and intricate series of experiments to control the nitro-glycerine, but he attained no success until he introduced infusorial earth, when he found it possible to tame the devastating agent completely. Forthwith he christened the new product dynamite, which, being several times more powerful than gunpowder, and all things considered safer and easier to handle, has come to be recognised as the premier explosive for mining purposes throughout the world. It is somewhat strange that the discovery of one earth, which heretofore had aroused only slight interest, and that for the most part among the worshippers of the beautiful in a minute form, should become the primary agent to facilitate and extend the wresting of every other known treasure from Nature's wonderful cave.

CHAPTER XXI

Treasure Winning as a Profession

"NOBODY can see into the ground!" This is the hoary precept of the miner and the prospector, and it must be conceded that it is an argument impossible to dispute. The scientist can only theorise; to attempt to dogmatise is absolutely fatal. All that the expert can relate, with any degree of certainty, is that such and such a mineral should be found here, there, or somewhere else, *if* the configuration and disposition of the strata of the earth coincide with the deductions he has formed as a result of intimate study of the situation, supported possibly by the evidence of exploratory drilling. But Nature plants her treasures in such out-of-the-way and unexpected places, and so endeavours to confound the scientist. If one desires to obtain conclusive and exasperating illustration of this fickleness upon the part of Nature one need only participate in an oil rush. The field may be covered as densely with the characteristic derricks as a window-pane in winter with the picturesque floral work of Jack Frost. They may be touching one another, the wells being sunk twenty feet apart; but one well may fail to strike oil, while those on all sides will plunge plump into the underground reservoir. The oil may be missed by the proverbial inch, but it will be missed all the same.

If the prospector had listened to all the reasonings of science, and had acted upon the advice extended, not one-half

of the mineral wealth now being extracted from the earth would ever have been found. The prospector is a law unto himself. He listens to nobody, and will decline to accept any advice in connection with his work. He knows full well that the expert is not provided with eyes invested with the capacity to peer into the earth, and consequently holds the expert in contempt. I had one interesting illustration of this perversity. The geologist attached to a certain Government was instructed to report upon a particular area and its coal deposits. He spent months on the site probing the earth's crust in all directions, and making a critical examination of the surface indications. He drew a blank, and expressed his emphatic opinion that no coal was to be found in that district. I happened to be in that territory and spending a few days in a prospecting camp. The men were looking for coal. They laughed at the expert's opinion, and, as if animated by motives of sheer antagonism, were engaged on a hunt for the mineral. They found it; and the amazing feature of the discovery was how the geologist ever came to miss it, because as a result of their persistent scratching yard by yard over the country, which they thought would be fruitful, the prospectors found an outcrop. It was followed up; tunnels were driven into the hillside and rich veins were tapped. To-day coal is being shipped from that region in increasing quantities to supply the homes and furnaces of the world.

It is the prospector's utter flouting of constitutional law in regard to the geological formation of the earth's crust which has been responsible for penetration to Nature's wonderful Aladdin's cave from a million and one different points. He is a happy-go-lucky nomad of the finest water, but one in whom the instincts of adventure are firmly planted. He

knows no boundaries and recognises no political frontiers, and in turn he appears to be tacitly regarded by all nations as a legitimate peaceful law-breaker. With his gun, prospecting pick, horse, and as slender a supply of food as he can carry, he ventures into the wild and unknown. For months nothing will be heard of him. He lives as best he can, calling upon the forest and stream to furnish his larder. He crawls laboriously through yawning ravines, plunges boldly into unsounded creeks, and scales precipitous heights, his eyes glued to the ground to be arrested by any unusual or curious marking of the rock or variation in the soil. All treasure comes alike to him. He works as he thinks he will, and as long as he feels so inclined. He is no respecter of property; he declines to bow to the law of trespass. It must be admitted that he is regarded kindly by one and all. The owner of a tract of country would never for a moment chase a prospector from his estate, although he would not hesitate to evict a waster of the gipsy tribe. The prospector may, as a result of his diligent scratching, tapping like a woodpecker with his little pick against the rock, or persistent panning of alluvium, suddenly make a strike capable of bringing wealth untold into the pockets of the owner.

The prospector is a student of the school of hard knocks and grim experience in which hard luck predominates. From morning to night he thinks, talks, and argues minerals, while even when asleep he often dreams of the wealth which he seldom appears to win. He is a picturesque personality, rugged of manner and taciturn in companionship; the silence of the woods has eaten into his soul. Yet round the camp fire at night, should his tongue be loosened, he is a wonderful raconteur, for every hour in his life is crammed with adventure in some one or another form. He has no enemies

other than the claim-jumper, for whom he has an unfathomable hatred; his honesty is amazing, and the lengths to which he will be trusted comes as a shock to those saturated with ideas incidental to residence in so-called civilisation. A prospector can always be trusted; he will always discharge a debt at the nearest store or saloon when he makes his strike.

At one up-country camp in the extreme north-west corner of Canada the store-keeper, out of amusement, produced his account against certain prospectors who were among his patrons, and who at the time were buried in the wilds. There were only six accounts, but they totalled two or three hundred pounds. One had been running for years, and only slender payments had been made at rare intervals. The next day the prospector who owed the largest individual sum suddenly turned up. He was agog with excitement. He had made a strike of something or other, the precise nature of which he did not communicate. He sold it for a few hundred pounds, and upon receipt of the money his first mission was to call upon all to whom he owed money, and to discharge his obligations. By the time he had completed his voluntary task he had only a few pounds left, but he was more than satisfied. After a brief spell of enjoyment he went off on another foraging expedition among the mountains, having restocked himself on credit once more at the local store.

To conduct prospecting along what may be described as essentially preliminary lines but little knowledge is required beyond what can be acquired in the field. Intimate association with the earth, rocks, and streams speedily acquaints one with their peculiar characteristics and the distinctive indications of mineral. The one and only requirement to carry out work upon these lines is temperament. The life

is hard and prospects always in the air. One must live in a "castle in Spain;" the whole while, be wholly dependent upon one's own exertions to subsist and to progress through the country, and place an implicit faith in Providence. In the northern countries work in the field, as active search among the mountains and creeks is called, is confined to the summer months; the winter is too rigorous to permit residence in the wilds, while the blanket of snow precludes all chance of conducting active search among the rocks. Then the prospector either comes in to secure some description of recognised employment, such as lumbering or other occupation demanding little skill, mainly to obtain subsistence during the winter. Maybe he will not come in at all, but endeavour to eke out an existence, and a certain precarious livelihood, by trapping. I have met prospectors who have not been near a community or seen a soul beyond a wandering Indian for three years or more, but having penetrated a district rich in fur they were able then to pass the winters profitably if not comfortably.

It is a doubtful point whether the world at large really appreciates the part played by the rugged lonely prospector in thrusting aside the veil of the unknown. Hargraves riveted the attention of the world upon Australia by his discovery of gold in New South Wales in 1851, a discovery which, as our kinsmen picturesquely relate, "precipitated Australia into manhood." The discovery of diamonds opened up first the western desert and afterwards the Rand, as well as driving the forces of civilisation northwards to settle Rhodesia. It was the discovery of gold in the Klondyke by Skookum Jim and his colleague which opened the Yukon territory, and led to the subsequent investigation of the commercial possibilities of Alaska. The discovery of

the gold fields of California led to the building of the first railway from coast to coast, across the breadth of the continent, unlocking rich agricultural territories and treasure houses innumerable. It is the activity of the prospector that has diverted commerce into new channels which it has never known before.

In striking contrast to the roving prospector is the organised prospecting expedition dispatched to a defined district for the investigation of the local resources and their distribution. In this instance the prospector is a trained unit—one who has graduated through a theoretical and practical school as distinct from the man who is dismissed as a soil-scratcher. As a rule he is a specialist because the field of mining is so vast, and contemporary effort decrees that it is preferable to select the specifically trained man for a specific class of work. This is the field which the young man, to whom the practise of searching for natural wealth and treasure trove makes distinct appeal, should strive to enter. It offers all the openings for success which may be desired, and is flavoured with the spice of adventure. His prototype, the picturesque prospector, is rapidly passing away. As a country becomes settled, he is forced farther afield, because in the unlocked territory he realises that he stands but an indifferent chance against well-trained and thoroughly schooled method.

Moreover, these expeditions, in addition to being well organised, are thoroughly equipped, while work is conducted systematically. Bases are established and supplies of provisions are assured to sustain the party. A modern prospecting enterprise may be compared with surveying for a new railway through a new country. The members of the party are not content with merely finding surface evidences of the

mineral. The ground is minutely surveyed to determine its characteristics, the approximate area of the location, as well as to obtain an indication of the amount of preliminary work which will be necessary to bring the deposit into production. If the mineral be of a metallic character field assays will be conducted to determine richness and yield.

Obviously, to carry out such work with the requisite degree of thoroughness demands knowledge, and this cannot be acquired except by years of study and a complete period of training along constitutional lines. It is necessary to master the science of geology not in the strict geological sense, but in its relationships to mineral bearing, or, as it is more concisely and positively described, mineralogy. This is a somewhat ambiguous term, because it does not embrace all and everything connected with the mineral kingdom, but refers rather to the simple or straight minerals. When the complex minerals are involved geology proper may be said to enter the field more pronouncedly.

Contemporary mining has become such a comprehensive term, and the winning of wealth from the earth involves the search and recovery of such a diversity of materials, as to have compelled subdivision of the subject. Forty years ago the minerals in demand by commerce and industry were relatively limited, and for the most part were simple. That is to say, if copper were sought the ore was treated wholly and solely for its copper. Other minerals which might be present, with the exception of gold, silver and lead, were generally ignored, while, of course, such materials as tungsten, osmium and other comparatively rare substances failed to arouse the slightest interest for the simple reason that commerce and industry did not call for them. But to-day there is a use and a certain demand for practically every

mineral encountered. If no application for a specific substance happens to exist the chemist sets to work to ascertain promising fields for its utilisation.

In these circumstances we find specialisation holding the field to-day. One may be an expert in diamond, coal, gold, silver or iron mining; or one may have made the recovery of earths or oils the prime study. The tendency to roam over the whole field is being more and more discouraged, although, of course, if one be specialising in geology with the intention of entering such an institution as the American Bureau of Mines, or seeks to occupy the post of government geologist, the net of knowledge and training cannot be cast too widely.

The practice of the science of mineralogy may be said to represent the elevation of the rude craft practised by the picturesque nomadic prospector to a science. Proceeding farther one enters what becomes the province of the mining engineer. The line of demarcation obtains, but it is exceedingly slender. The relation between the mineralogist and the mining engineer may be compared with that prevailing between the chemist and the chemical engineer. The one may know but little of the other's side of the problem; on the other hand one may be accomplished in both fields. The engineering side, purely and simply, is by far the largest and most attractive. In this instance it is requisite to be skilled in knowledge, not only of engineering in all its branches, but to have a fairly comprehensive idea of mineralogy as well. In so far as the engineering phase alone is concerned it involves mastery of the craft as it pertains to civil engineering for the sinking of shafts, driving and shoring up of tunnels, wrestles with stretches of bad ground dealing with faults and drainage, to mention

only a few of the issues involved. Then there are questions concerning haulage, ventilation, pumping, lighting, and surface operations such as washing, screening and cleaning to be studied. To-day, owing to the increasing utilisation of electricity for power, a further stress is imposed upon the capacity of the presiding genius. Of course, extensive subdivision obtains, but then it must not be forgotten that the man at the top is supposed to know everything.

Furthermore, each method of winning the treasure differs from its fellows. The problems encountered in connection with open workings are markedly different from those met in underground operations, while dredging has little in common with either. Then one must not forget another aspect—the winning, or the recovery, of the metals from their ores, as for instance, the smelting of copper and the successful extraction of any by-products which may be present. Here we find the chemist in request, in itself a special branch of that far-flung craft.

The demand for qualified men having specialised knowledge in certain phases of the craft has resulted in the establishment of institutions devoting their whole energies to the distribution of knowledge bearing up the science, while all our universities, more particularly those situate in mining districts, have faculties of geology, mining and surveying, and engineering respectively. To the young man contemplating mining as a profession he cannot do better than to peruse the syllabus issued by such universities as those of Oxford and Cambridge (Geology, Chemistry and Mineralogy), London, and the universities of Manchester, Durham, Liverpool, Leeds, Birmingham, Sheffield, Wales, Glasgow, Aberdeen and Dublin, while many of the leading technical schools and colleges distributed throughout the

country give a practical training in the craft. Lastly, there is the Royal School of Mines, which in regard to the mining profession holds a unique position throughout the world.

Six years ago the Germans were generally held to give the finishing touch to the student's mining education. To have graduated at Freiburg was held as a cachet to the plums of the profession. In common with all things German, however, the polish imparted by Freiburg was evanescent. To the graduate who had acquired knowledge at the British School of Mines a spell at Freiburg was in the nature of a holiday. It became recognised in many countries that, instead of the German education being superior to that imparted by the rival British institution, the position was reversed. A term or two at Freiburg developed more into a fashion than as a serious development. It was only when the students graduating at the two schools were thrown up against troubles in the field that the true worth of the curriculum extended at the respective institutions became manifest. The German mining engineer and he who had been trained wholly or for the most part at Freiburg succeeded only so long as developments coincided with the book; when it came to the display of initiative to cope with something unexpected, or out of the rut, it was always the British trained engineer who came to the top to demonstrate his ability to cope with the situation.

Resource in mining, as in every other profession, is always an invaluable asset, and it shows up to greatest advantage when training has been conducted along correct lines. Probably, in future, we shall hear less of the much vaunted advantage of Freiburg training. Beyond proving a source of considerable revenue to the Saxon Government, the fees

in which foreign students are mulcted being distinctly on the extortionate side, doubtless for the privilege of being able to use the professional trade mark "Freiburg," was similar to Prussian military supremacy—an overblown bubble. Great Britain is quite capable of imparting to the young man all the knowledge he will ever be likely to require to wrest the wealth lying in Nature's wonderful Aladdin's Cave.